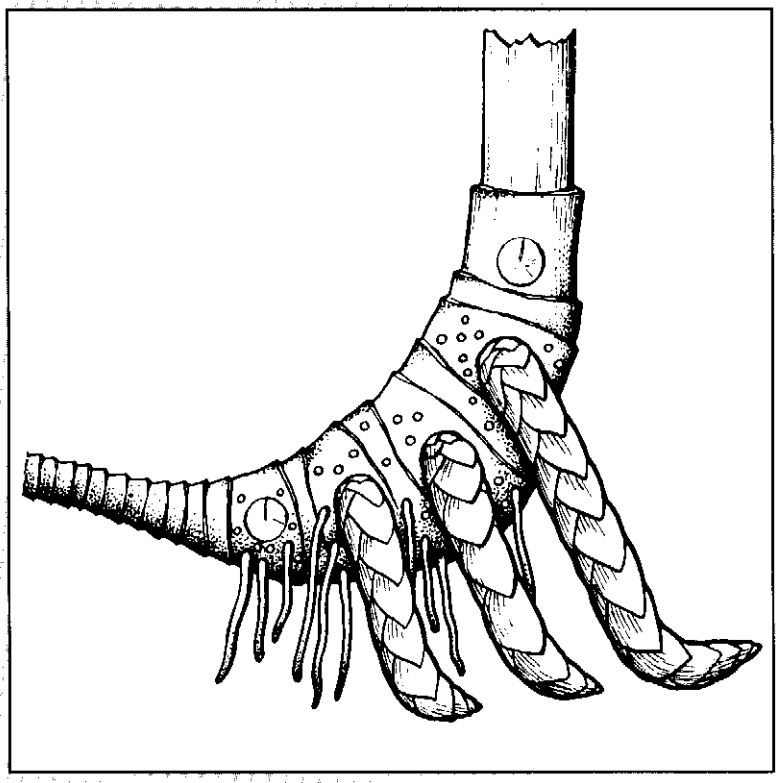


4. SHELTER: IN THE BEGINNING WAS BAMBOO

Things came before people.
People came before words.

Tall, green, and nameless,
bamboo walked down centuries
and crossed continents
in time to stand there, waiting,
naked of language,
when the first people came
to make the first village.

Lots more people means lots more houses. Bamboo outproduces any alternative source for the raw materials of construction. Growing walls and roof on the spot saves transport and materials cost, decentralizes the building business, unplugs it from banks, and humanizes shelter. The house is brought home again. You can grow your own, like tomatoes.

THIRD SKIN

Shelter is our third skin. Although everyone agrees everyone needs it, the housing shortage is ever more acute and ever more everywhere. Governments are dealing with unprecedented numbers demanding more as minimal housing, and as more line up for a roof, fewer are equipped with skills, tools, materials, land, and/or cash to weave a shelter around them of their own labor and will.

Shelter shortage.
More are moving more, which means more renters less attached to any one shelter, less experienced as owner-builder-menders permanently related to a piece of earth. Government low-cost housing projects around the world are never as abundant as needed, always beyond the means of the really poor, always a double-ugly crime zone miles wide of the cultural mark—and always erected with near zero planning and participation of the people.

Autoarchitecture forms part of the schooling of all traditional peoples. Only in fragmented modern education has building been abandoned as a central study. Are reading and writing and arithmetic more crucial than architecting our own dwellings? A world in chronic shelter shortage, an intense drama with a supporting cast of some 2½ billion, should reestablish popular architecture in its educational system from the earliest levels. And an integral architecture should plant as well as build: We should all be foresters as well as carpenters, growing the raw material as well as shaping it.

Unprecedented demand for human shelter demands in turn a deep rethinking of our cultural designs for it. Bamboo is examined first in two forms relevant to high-tech modern construction—lamination and bamboo reinforced concrete. Both are

In this sympodial rhizome of* Guadua angustifolia, *buds of the next generation form "feet" to help support the 100-foot culm growing from the mother rhizome.

appropriate in a number of ways for a decentralized village technology.

Disasters are sufficiently chronic in human experience for us to take the trouble to design their wake better. And in disaster design the need for "instant shelter" provides an intensified miniature model for the constant disaster area of present world culture, our wretched world housing, monstrously below any code of the heart. People participation has been observed as central in postdisaster designs to rebuild. That hint should be applied to the permanent emergency the homeless have become in our time.

In contrast to the sprawling, shallow, and money-dominated disorder of modern mass housing, the Japanese teahouse represents a wholistic response to the deepest psychological duties of a shelter design in touch with restrained human needs. The idea of an ultimate art, an all-inclusive art is present in many cultures. "Primitive" fiestas embody this better than any modern art form. A Hopi bean dance, for example, includes every art you could imagine—dance, song, drama, clowns, cooking, architecture, and god dolls or Kachinas: the theology and cosmology of the Hopis embodied in beautifully painted and costumed cottonwood statuettes given to children as a catechism of Hopi myth at fiestas. Elaborate jewelry of turquoise and silver, pounding on the chests of the dancers, becomes a percussion instrument.

Europe in the nineteenth century also dreamt of the complete work of art that would unite all the arts in its creation and found the opera. Architecture provided the buxom embellishments of the standard opera house, the construction of which provides few hints about mass housing: It is a glittering exception, not the possible norm.

The tea ceremony is another of these total art forms weaving many arts into a coherent unified expression. Its summation of Japanese culture, within a tiny space and intimate ritual, was effective and seminal: The simplicity of the form made it available at all social levels, and the teahouse became the dominant philosophic and design influence on what we know today as the characteristic Japanese house.

Architectural activists.

Feeding the people doesn't mean putting every spoonful in their mouths but being sure that food and fuel are available in sufficient quantity for everyone. Sheltering the people should not mean housing projects but making resources available, reawakening traditional skills, and playing midwife to new forms of old solutions so people can resume responsibility for self-shelter.

The true task of governments with respect to housing is to help create the conditions for a culture of architectural activists. This emphatically includes reforestation designs geared to the needs of a popular architecture.

LAMINATION

New forms of the ancient technology of lamination may be opening the biggest door for bamboo in contemporary industrial design. The Chinese employed plybamboo in the vanes of winnowing machines in the eleventh century, and Japanese bowmakers were laminating bamboo with wood for centuries before large-scale modern uses of the process in the West in 1907, when the first architectural members of laminated wood were made in Europe. Laminated woods were used in airplanes in World War I and later in U.S. factories, gymnasiums, hangars, and houses from the middle thirties on. Laminated bridges and marine structures followed the development of new glues and resins, with which laminated spans up to 174 feet have been made in the United States.[1]

Bats, rackets, and parquets.

The lamination process makes large pieces from small, even scrap, material without the splits and fissures common in large timbers. Within certain limits, lower grade woods can be used without affecting the strength of the final laminated product. As smaller and inferior grade trees appear on the pinched world lumber market, lamination will increase as a process with a thousand applications, and laminated bamboos will be taking over more and more of the tasks performed by laminated woods. The same rapid proliferation that has occurred in the brief history of laminated woods can

Laminated bamboo plate.

be expected in products of laminated bamboo, many of which are already on the market. Laminated bamboo plates, cups, bowls, trays, screens, bows and arrows, tennis rackets—scores of traditional objects and bizarre East-West hybrids such as laminated bamboo baseball bats have, for some time now, been exported widely from Taiwan and Japan.

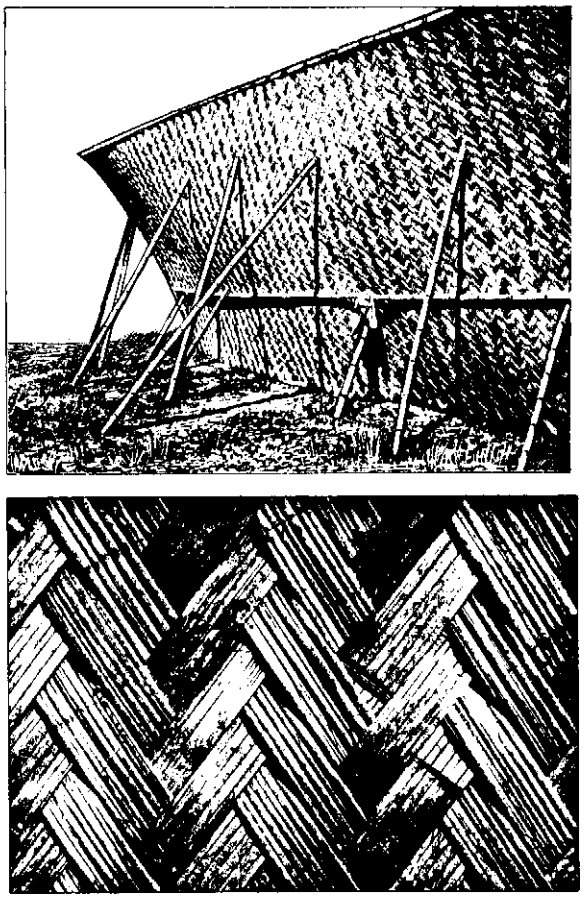
Bamboo tile, parquet for floors, thin rollable bamboo veneer, as well as plybamboos of woven matting are now available, and many more objects presently made in plastic can and probably will be made of bamboo as lamination extends the natural versatility of the plant. Plastics are petroleum based and polluting, while bamboo creates lots of oxygen as well as crude cellulose fiber. Countries can't move oil fields to their back yards, but they can plant bamboo. As nonpolluting, replenishable, biodegradable substances are welcomed by ecologically conscious industries—somewhere in the uncertain and finite future of petroleum—laminated bamboo may replace plastics in many more roles.

Plybamboo.

In rural areas of the world, bamboo will continue to be used as it has been for many centuries—in unprocessed poles, cut to the desired length with a machete, flattened into boards with an ax, or woven into long mats and sold by the finished yard. But the most promising future for bamboo in urban housing lies in the direction explored by the Forest Research Institute at Dehra Dun (India). Narayanamurti (1956) summarizes—in "Building Boards from Bamboos"—seven years experimental production of woven panels of plybamboo for moulded furniture and prefabricated ceilings, walls, and floors for economical housing.

The appearance, strength, and durability of desk fronts and dressing tables, folding screens for room dividers, drawers, sewing machine covers, suitcases, wardrobes, and architectural elements manufactured were considered very encouraging. *Bambusa arundinacea, Bambusa polymorpha,* and *Dendrocalamus strictus* were the principal species used, with the first showing greatest strength.

Successful experiments were conducted producing flakeboards from shavings and sawdust of bamboo, but most work was done with bamboo mats, woven by hand or on a loom modeled after a textile-weaving machine, using strips of varied width approximately $\frac{1}{16}$ inch thick. Mats were soaked in a resin solution and then pressed—usually three together—at 140°C. A resin solution of 15 percent and pressure of 400 pounds per square inch were found to produce satisfactory boards. "Single mat boards are flexible and very suitable for light partitions or ceilings . . . The bamboo strips can be interwoven with veneer strips or special wood shavings. Bamboo shavings sprinkled on the mats before being pressed produce a very attractive surface." (Sawdust, sand, charcoal, and cork dust were also tried for filler.)



Prefab walls of woven bamboo are common in oriental countries. (A) **Muli (Melocanna baccifera),** ***a major species of India. (B) Detail. Note the nodes; each strip is a whole, flattened culm.***

Boards proved quite water resistant. Specimens soaked in water were sound even after three years. Boards buried in the Institute test yards at the end of seven years were still unattacked by termites and fungi. This resistance can be further increased by adding a small percentage of pentachlorophenol to the resin solution. A building with floor, walls, and roof of bamboo boards had survived, at the time of this writing, five years with 85-inch annual rainfall and was still in good condition. The boards used had a filler of sawdust and were produced at

the comparatively low pressure of 200 pounds per square inch.

Some notion of the feel of finished products in plybamboo can be had from the laminated bamboo plates produced by a similar process in Taiwan, China, and Japan, which are broadly available at low cost in the United States. They are incredibly light yet strong.[2]

Plybamboo is a relevant direction for research because its technology is simple enough to fit decentralized village production for local use. Fabrication relies on basic traditional weaving skills found in most areas where mats and baskets are made with bamboo and a wide range of other grasses, reeds, and vines. The use of plybamboo in eleventh century China suggests the low-tech, village industry feasibility of this shelter material. Plybamboo represents a revival of an ancient process wed to the common practice through many parts of Southeast Asia of weaving long prefab walls of split and flattened thin-walled bamboos. *Schizostachyum* species are used in the well-known Philippine version of this woven wall called sawale. A 1-inch-diameter bamboo, opened out flat, yields a strip as long as the culm, roughly 3 to 3½ inches wide, a large member for rapid weaving ease. In some areas of Asia, walls up to 30 feet long and 10 feet high are woven, rolled up, and delivered to the house site by ox cart. Such rural technologies provide a sound traditional base for plybamboo development, but one urgent priority in countries with abundant bamboo is the search for native resins that will free plybamboo from costly imported adhesives.

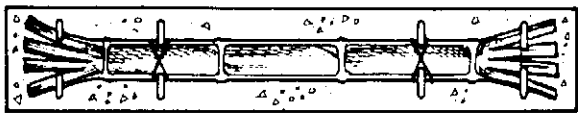
REINFORCED CONCRETE

Use of bamboo in construction has, until now, tended to diminish with increased industrialization. For example, India, with a population still largely rural, uses 150 times as much bamboo for construction as Japan—and one-quarter as much for manufacture. But with bamboo now available in a contemporary industrial format as laminated panels and structural members for the skin and frame, these figures could change greatly in industrialized countries like Japan. And the use of bamboo to replace expensive iron rods in reinforced concrete may do as much as lamination to alter the profile of world use.

Around 1918, the Chinese were the first at studying bamboo to replace iron in the reinforced concrete of railroad bridges and other constructions. It was employed by both the United States and Japan during World War II, and its usefulness to the military in Vietnam recently spurred more research in America. The industrial implications of bamboo used as reinforcing rods are enormous, and detailed research has been conducted in a number of countries including China (1920s), Germany (1935), and the United States (1943, 1968).

Barn swallows and other species built mud shelters reinforced with twigs and fibers. Wattle, daub, and reinforced concrete are recent evolutions of an ancient technology.

Until now, it has been primarily the crisis conditions of war that have intensified interest in bamboo as a possible replacement for needed metal in construction. Technologies using available on-site material are preferable in wartime to reliance on vulnerable supply lines. However, many products and processes first tried in the military have found their way into the domestic, peacetime economy. Refrigerators were first used not in family kitchens,

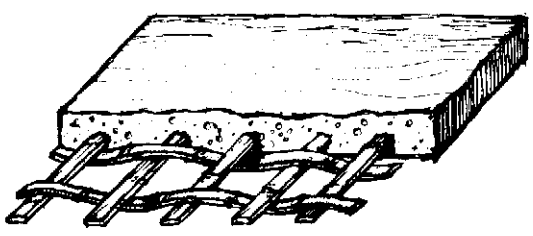


but on battleships. Bamboo reinforced concrete may follow this route from weaponry to "livingry," as Buckminster Fuller called the peaceful ending of this familiar pattern. Population growth and the rising costs of steel and transportation may soon prove sufficient to stimulate increased use of bamboo cement, especially where bamboo is locally abundant.

Fortunately for world housing needs, the areas of the most rapid population growth are also generally the areas with the largest growth of bamboo, or at least with climates friendly to its growth. Latin American governments especially, short 20 million houses now and facing the world's fastest population doubling rate, intensifying that shortage, are going to be turning to bamboo.

South Carolina experiments.
Bamboo reinforced concrete experiments have been conducted since roughly 1917 in China, Japan, and the Philippines in the East, and by Germany (1934) and Italy in Europe. Various applications have also been explored by Oscar Hidalgo (1974, 1978) in South America. The most comprehensive experiments to date in the United States were conducted by Glenn and associates (1950) at the Clemson College of Engineering in South Carolina. McClure reprints their conclusions and construction principles in full.[3] Some highlights of their summary: Bamboo reinforcement in concrete beams increases the load-bearing capacity of beams most effectively when it constitutes 3 to 4 percent of the cross-sectional area of concrete in the member. Reinforced beams bore four to five times the load of unreinforced beams of equal dimensions before failure occurred; they can be safely designed to carry two to three times the load of unreinforced beams.

In concrete slabs and secondary members, green, unseasoned, whole culms up to ¾ inch may be used but are not recommended for important concrete members. When possible, allow a drying period of three to four weeks before using. Only fully mature culms, three years or older, should be used. Alternate base and tip of whole culms because this makes for a uniform percentage of bamboo in cross section and creates a wedging effect that increases bond. "Apparently, the bamboo reinforcement of nonload-bearing members, such as wall panels and floors resting on well-compacted earth, has more to recommend it than bamboo reinforcement of load-bearing members of a structure."[3a] Before pouring, request information from Dehra Dun (next section) and consult the Glenn study in detail to avoid repeating their mistakes.



Cross section of bamboo reinforced concrete slab.

Report from Dehra Dun, India.

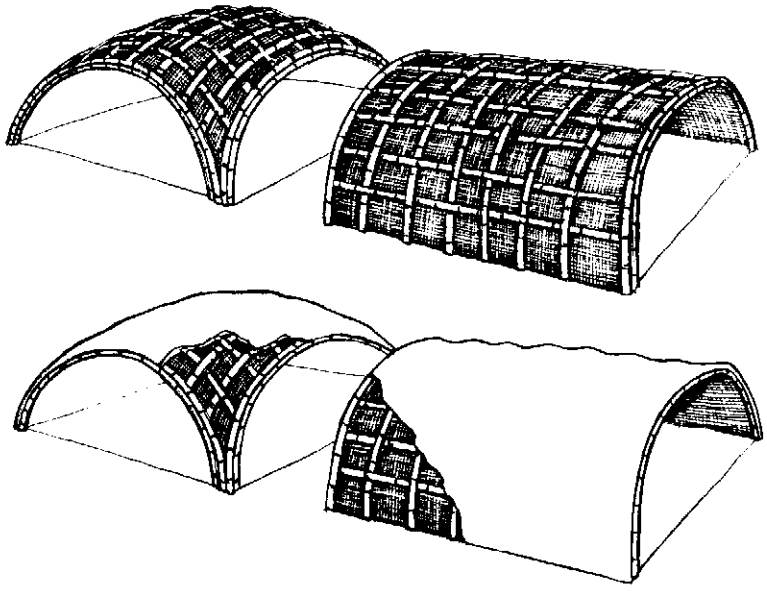
> To save steel in the country, a research program by the Timber Engineering Branch tested bamboo as a reinforcing material in various cement concrete precast and cast-in-situ structural components. High absorption of water from cement concrete initially resulted in dreadful cracks in the concreted components and discouraged the engineers. However, suitable, easily applied water-repellent has been found, resulting in safe structures: by dipping bamboo *(Bambusa arundinacea)* strips, 20 by 9 mm, in 80/100 grade hot bitumen and sand blasting, the bitumen acts as water-repellent, and the sand coating helps increase bond. After drying, the bamboo strings are tied into a mesh as is usually done.

These investigations showed bamboo use in place of steel reduced costs 33 percent.

A number of full-scale demonstration and use structures have been built to observe behavior under long-term loading and operation. These structures include a double-story residential block with a variety of structural components ranging from a sunshade to a grain silo. The results are encouraging and more such structures are planned.[4]

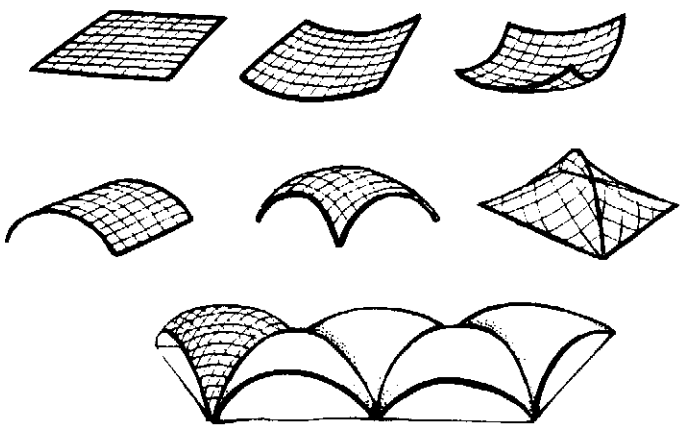
Lattice structures.
West Coast U.S. bamboo architect Jim Orjala sees the Glenn experiments as insensitive to other design possibilities with bamboo, such as lattice structures. Traditional bamboo lattices, from basketry to roofs, developed out of familiarity with the flexibility of bamboo and its strength in tension. The bamboo lattice when curved, or "prestressed," gains considerable strength in its ability to span space and resist bending due to external compressive loading.

The bamboo lattice, thinly coated with lightweight cement to aid in taking compressive



stresses, provides a structure of exceptional efficiency and economy in the use of materials. Major problems encountered in previous work with bamboo can be traced to the structural systems employed: beams, slabs, columns. Beams, the most inefficient structural members, are particularly subject to bending due to concentrated perpendicular loading. The beams tested failed ultimately due to failure of the bond between the bamboo and concrete. Physical characteristics of bamboo, in comparison to steel, make bonding with concrete difficult.

Techniques developed for thin-shell ferrocement vaults and domes offer significant potentials to alleviate these problems. The curved bamboo lattice is similar to steel mesh used in ferrocement. Vaults and domes are particularly efficient structural systems. The structural advantages of these forms lie in dispersal of stresses along the curved surface, which effectively minimizes bending. A higher percentage of reinforcement provides more surface for bonding. Distribution of reinforcement significantly reduces concentration of stresses on the bonding and allows greater resiliency of the composite material.

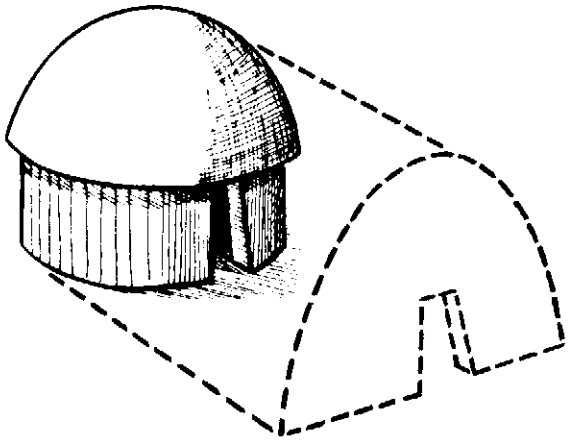


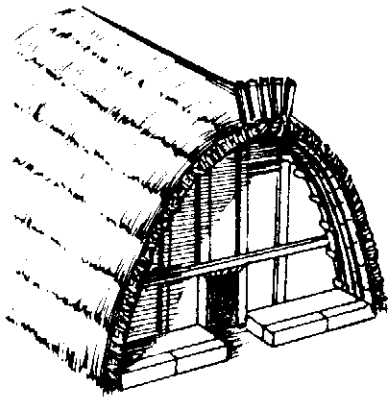
There are several other advantages to the lattice framework as well: it requires the simplest of skills and techniques for plastering. Labor and cost of formwork are eliminated. The use of bamboo in place of steel further reduces the weight and cost of reinforcement. The thin coating of cement significantly reduces the weight, quantity, and cost in comparison to conventional concrete construction.[5] See also "Water storage" (pp. 66–67) on Thailand's recent work with bamboo-reinforced storage tanks for rural areas. Hidalgo (1978: 82–127) is highly recommended for extensive how-to photos, exploring low-technology production of bamboo-cement roofing, tanks, panels, fence posts, and beams. Cables of twisted strips of bamboo, designed to increase bonding, were an innovation of these Colombian experiments.

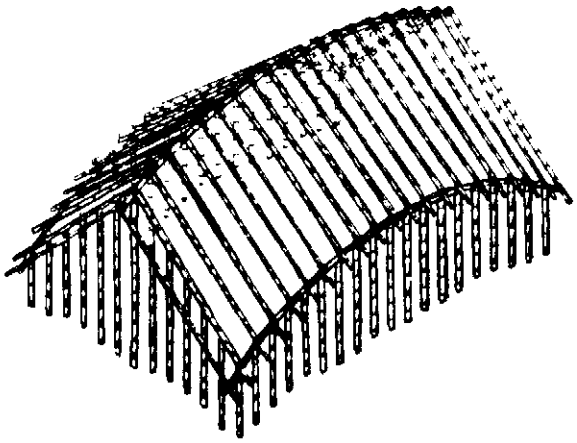
QUAKING WITHOUT BREAKING: BAMBOO CITY PLANNING

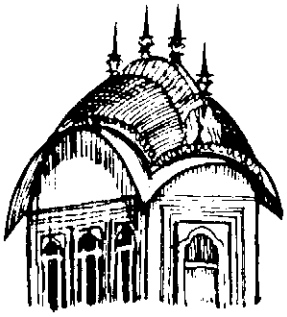
Of the half million earthquakes rippling the earth's surface annually, some one hundred thousand can be felt. Of these, one thousand cause some dam-

Bamboo design models. Evolution of the original round bamboo hut in India. Bamboo was a structural element in the earliest shelters of Asia not only because of its abundance, but also because crude tools could work it easily. In some areas of the world where native peoples enjoy the options of large hardwood forests and groves of bamboo, the latter is still chosen for houses for the same reasons that first determined its use: ease of harvest, transport, and construction.

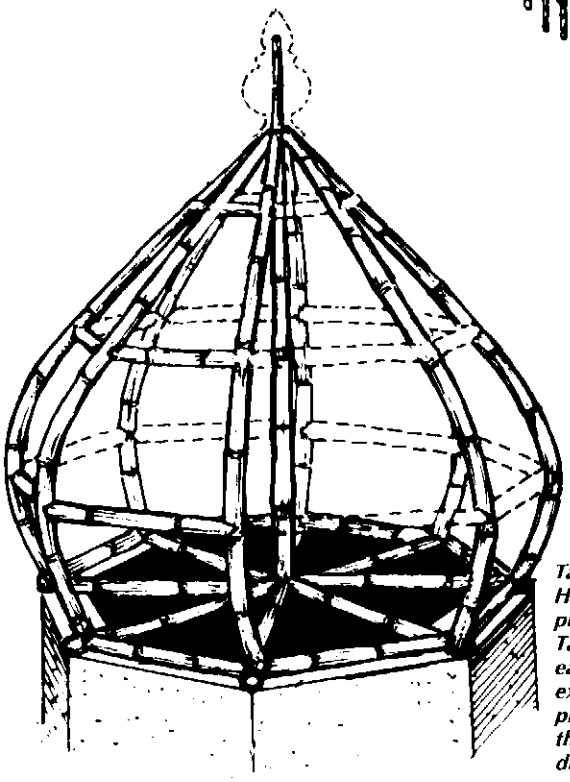








Chauchala *(India). Wood and stone became important building materials as primitive tools grew more sophisticated. This trinity of bamboo, wood, and stone reflects not only the architectural evolution of the Orient, but its social classes as well. The poor used bamboo, and the rich, wood; stone was preferred for the palaces of princes and the temples of priests. Bamboo continues to be the wood of the poor, particularly in India, where some 500,000 tons are used annually for housing.*



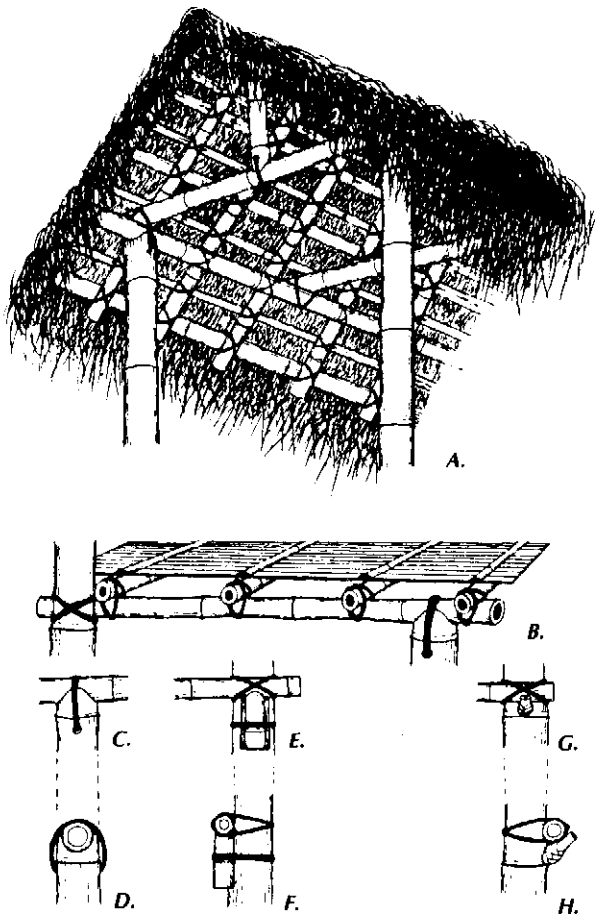
Taj Mahal. The cupola of Hindu and Buddhist temples and the dome of the Taj Mahal are examples of early bamboo architectural explorations finding expression centuries later in the more permanent medium of masonry.

age. Three times a day, a quake somewhere is tumbling things back to earth. Quake-zone city planners can ponder the Japanese tradition that a bamboo grove is the safest place to be in an earthquake. Dense growth of bamboo around a building functions in the soil as windbreaks act in air: rhizomes buffer the blow and diminish the intensity of motion. Widely planted in any quake zone, bamboos absorb much of the earth's ripple, moreover provide immediate construction material for temporary disaster shelters. "Scenario" has become a cliche of war games. "What if bomb A fell on city B?" In order to hint how bamboo development could occur, let us imagine for a moment a true lie, a tale botanically and socially possible, but which never occurred. It sketches an imagined collaboration among government agencies, mass media, the schools, and the people that is probably a precondition for any durable and deep cultural innovations with bamboo in our times.

Managua 1972: rebuilding with bamboo.
Managua provides an interesting example of how bamboo can relieve disaster in a tropical climate. In December 1972, the city "trembled like a wounded animal," as one survivor said, and the Nicaraguan people were left with a demolished capital to repair. Central Managua was in ruins, with thirty thousand dead and many thousands homeless.

Bamboo houses are common in Nicaragua, especially in the rainy northeastern part where some 50,000 acres of bamboo grow mainly along a number of rivers emptying into the Atlantic. Many Managua residents—often the oldest members of the household—had come from rural areas where rustic bamboo constructions were common. Two species of bamboo useful for building grew some 40 km south of Managua. For a number of reasons, it was natural that disaster housing was partly erected with bamboo. It was light to transport; some 700 poles fit into a truck with a 4 by 9 by 15 foot bed. It was rapid to work with, requiring only a machete to cut, split, and shape. Basket makers from the Masaya area, the craft center of Nicaragua, were brought in to show people how to weave bamboo panels. From this beginning, sprang up small workshops producing prefab panels woven to specific dimensions.

The basket makers also taught some Managua residents how to plant. The freshly cut culms of *Bambusa vulgaris* they were building with could be propagated easily from basal nodes and wasted



Basic bamboo construction: (A) fitting and binding culms at joints in roof and frame; (B) fitting and securing bamboo boards in floor; (C and D) saddle joint; (E and F) inset block to strengthen support of horizontal above; (G and H) use of branch stump for support.

branches. One barrio organized a larger planting in a park and playground area. It gave quick shade, extended in a few years by using bamboo arbors for chayotes, calalas, and other climbing plants, which provided food in the inner city without transport as well as large leafy roofs to gentle the oven of city air, torrid enough to inspire a popular joke: "When Managuans die and go to hell, they send home for their blankets."

Integrated development.
The municipal reconstruction offices in Managua responded to the people's spontaneous plantings of bamboo by beginning groves in completely empty areas scattered throughout the quake zone where no building was contemplated. They planted two drought-resistant species, *Bambusa ventricosa* and *Dendrocalamus strictus,* and other bamboos from the government collection of oriental tropical spe-

cies in El Recreo, Zelaya. More delicate species like *Bambusa textilis* were mulched heavily and planted under vine-bearing bamboo arbors until they were well enough established to begin shading themselves.

Urban umbrella: bamboo microclimates.
The ministries of agriculture, education, and housing were involved in the Managua bamboo project design, as was the architecture school, *Universidad Nacional Autonoma de Nicaragua* (UNAN). Articles appeared in newspapers, supporting and explaining the why and how of bamboo and urban planning. "One rhizome of *Bambusa vulgaris,* in a Colombian experiment to measure bamboo's capacity to increase and multiply, produced 200 culms in five years. Yearly growth is 2–5 percent of existing size in most tree species; in bamboo the annual increment is 10–30 percent. Managua can grow much of its needed construction material on location, saving enormously in transportation costs.

"A great deal of this new growth in bamboo is in its leaves, which do not increase the size of the culm they grow on, but nourish the underground system of rhizomes uniting the grove. These rhizomes, bamboo's energy bank, in turn produce more culms. Massively planted by students in the city's abundant empty lots, bamboo will change many microclimates in Managua, as the experience of Don Bosco and other barrios has proven, in fairly large plantings already almost two years old. Bamboo shadows the architectural madness of zinc roofs—low in altitude but not in cost or temperature. It muffles city noise, increases privacy, and screens buildings often less attractive than the plant. It can air-condition the torrid center of Managua, still virtually treeless since the quake."

City farming.
"The foliage of bamboo is evergreen and superdense. Reaching 4 inches per year in the leaf fall of some species, in others it equals the weight of the grove's new culms. Its green abundance accounts for bamboo's wide use in many rural areas of the world for animal fodder. It has been used as a supplement rich in vitamin A for chicken food,[6] and in the Andes, in both Ecuador and Peru, bamboo leaves are fed to guinea pigs, an important part of the local diet. Such uses in small animal husbandry have suggested the use of bamboo leaves for rabbit food and culms for cages in urban farming designs to increase meat production in the crowded city. Japanese yield studies found that two species measured produced 5–15 tons of leaves per hectare.

"This abundant foliage means that bamboo shade is quite tangibly cooler than the surrounding air and makes it perhaps the most intense injection of oxygen into urban exhaust that coughing moderns could plan."

Green air.
"A neglected aspect of modern urban architecture is a serious leaf/people disequilibrium. Never have so many people lived with so few leaves, nor dirtied their air more thoroughly in traffic jams trying to escape it—to the countryside, where we instinctively seek out a greater abundance of vegetation. The search is not surprising. More leaves mean more oxygen. Contemporary psychologists note that oxygen reduction in blood creates in brain cells a proliferation of negative emotions, fears, aggressions, worries—the whole configuration of antiother feelings which characterize the psychology of modern urban dwellers, sick of too much cement, too many faces, and too few leaves. Anyone who has experienced the refreshing atmosphere of dense stands of the plant will appreciate why, after enlightenment, the Buddha chose to live in a forevergreen grove of bamboo." (*La Prensa,* 14 October 1974.)

These figures are botanically accurate, but—except for the bit about the Buddha—none of the above actually happened. Nicaragua's dictator at

the time, Anastasio Somoza, pocketed most of the international aid sent for disaster relief, but even if he hadn't, it's unlikely anyone would have thought of bamboo. The reasons in favor of bamboo are multiple and complex; they cross the frontiers of too many ministries. Modern governments, fragmented into immense bureaucracies of specialists, by their very nature are ill-equipped to enact solutions that touch too subtly too many keys on the grand piano of cultural design. Ten years after the quake, Managua is still barren of trees, filled with empty lots, and experiencing a housing shortage that present building rates will require a century to meet. (The Sandinistas have, however, made tree planting in Managua a part of their platform, which aspires nationwide to an ecological sanity as bandage to a century or so of ruthless resource plunder.)[7]

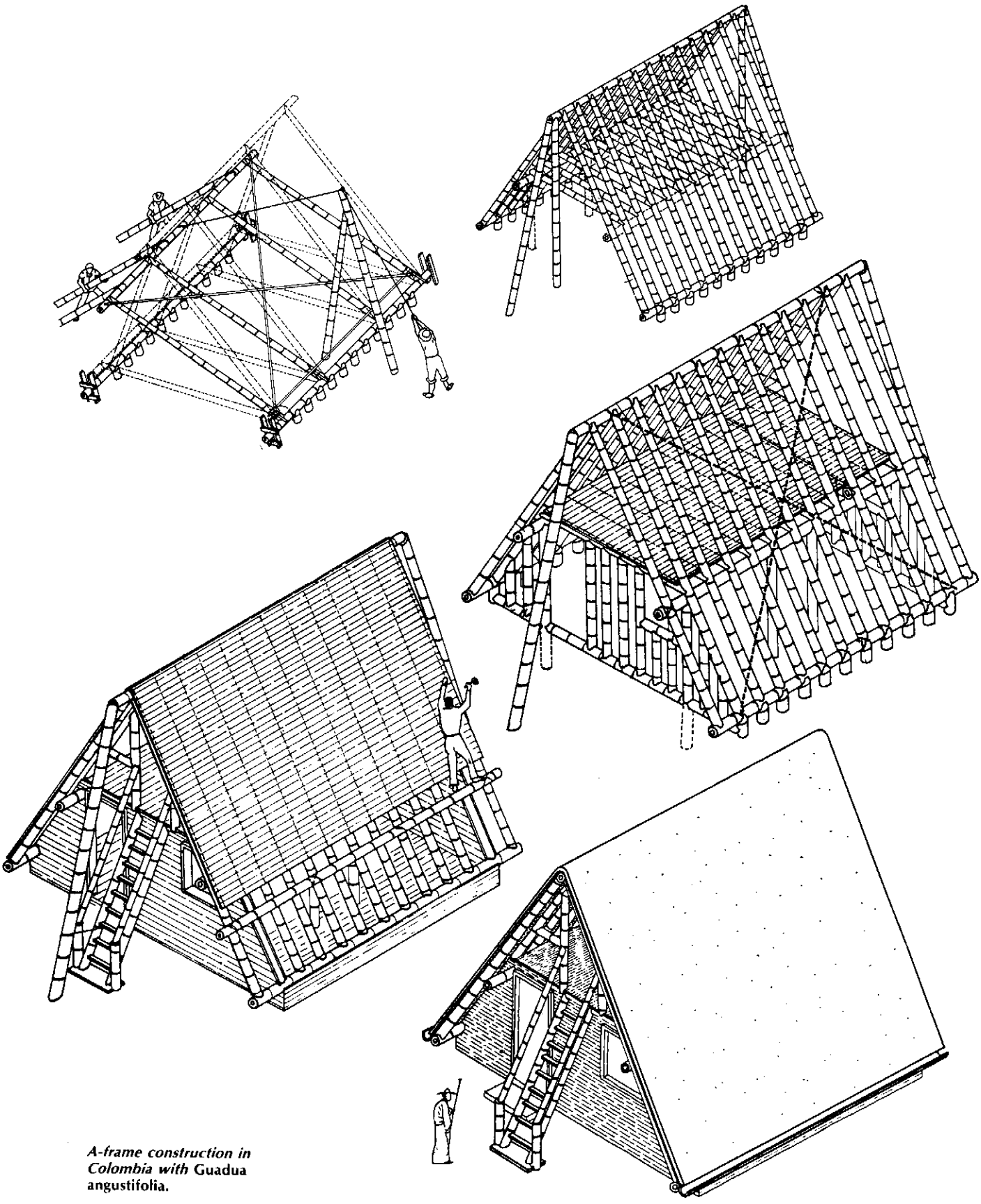
Disaster designs.
Massive, merciless bombing, and resulting masses of roofless refugees, must be added to earthquakes and other natural disasters as sufficiently recurrent to deserve advance planning. Someone has statistics somewhere on how many people, worldwide, are presently living in disaster architecture. Cost and quickness are two critical factors for disaster relief; another, often overlooked, is victim participation. Flying sophisticated equipment and crews in to spray a thousand polyurethane foam domes denies the people a chance to rely on their own creative energy: first they are knocked over by the weather or war, then high-tech generosity floods them with a solution alien to the context . . . and drives home a dismal sense of helplessness.

Bamboo is an alternative. Providing victims of natural or human disasters the wherewithal to create their own solution is more creative than a finished package usually designed far from the local reality. Green belts of bamboo in and around large population centers would be one intelligent and anticipatory practice in the tropical regions of its greatest growth. In *Shelter After Disaster,* Ian Davis (1978) examines three hundred years of human response to disaster—an increasing global experience as more people, especially in poorer countries, jam dangerous sites on precarious hillsides or hurricane-prone waterfronts. The victims' ingenuity does 80 percent of the cleanup—actively recycling rubble into new homes—if foreign aid doesn't steamroll in to frustrate their efforts. Experience indicates that international agencies and relief design should foster what the people are already doing instead of pushing an alien scheme and technology on them. Low technology, by contrast, is affordable by the people, affirms a reassuring continuity with traditions, and generates local employment. (See Darrow 1981: 661–2.)

Quake-zone construction.
The queen in *Alice in Wonderland* explains to Alice the advantage of advance weeping: it leaves you free to deal with the accident calmly when it occurs so effective response to tragedy of whatever dimension is unmuddied by emotional confusion. Routine plantings of bamboo long before disaster strikes could function as anticipatory tears, permitting efficient relief when suddenly needed. Similar in intent is a current housing project in Guatemala that features a retraining program promoting quake-conscious construction using traditional materials and known skills; it results in structures familiar in appearance but safer than traditional housing in the area.[8] Along the same lines, Narayanamurti, in the U.N. sponsored *Bamboo and Reeds in Building Construction* (1972), notes a variety of ways in which conventional bamboo and other low-tech structures can be made more quake proof: "Earthquake forces that a building has to withstand are proportional to its weight and are predominantly horizontal. The heavier a building, the more likely it is to get damaged. Lightweight material such as bamboo, with a high strength/weight ratio, is therefore preferred in regions where earthquakes occur.

"Experience in different seismic regions of the world has shown that a house built of bamboo, properly lashed together, is earthquake resistant. In this respect, bamboo is somewhat superior to timber. It has the capacity to absorb more energy, and shows large deflections before failure occurs. A bamboo frame structure yields readily to vibrations during a quake and does not collapse. If such a mishap occurs, loss of life and property are less in lightweight structures.

"Construction details should be adopted at the joints of the framing members and wall panels so that the bamboo frame structure as a whole behaves as one unit against earthquake forces. Experience in India suggests that a closed-frame construction should be adopted with horizontal connecting members for the columns at foundation level. Walls and partitions should be provided with diagonal braces and anchored properly to the vertical and horizontal struts. Observations on behavior of framed structures during earthquakes in Assam have led to the conclusion that the superstructure



A-frame construction in Colombia with Guadua angustifolia.

should rest on a foundation of masonry. Small, one-story buildings up to 50 square meters may rest on firm ground, but in larger buildings the posts should be attached to foundations by means of pins or straps, bolts, and nuts.

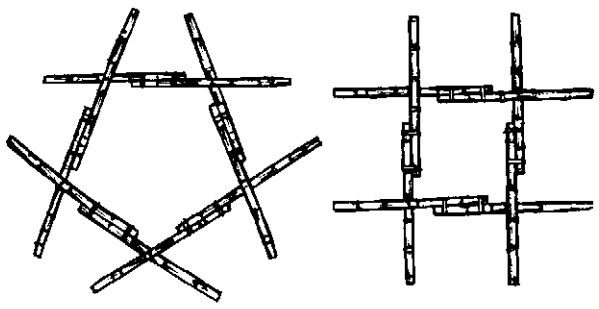
"Bamboo board, matting, and plastered matting walls, being light and flexible, are suitable for seismic areas. Experience in Colombia has shown that the *bajareque* wall construction, more massive than wattle and daub but less massive than rammed earth or adobe, is earthquake resistant. Load-bearing adobe and heavy mud walls, which fail under relatively slight tensile or bending force, are the first to fall during a seismic vibration. It is recommended that a bamboo lattice should be used in mud walls to strengthen them.

"Brick masonry walls also have poor resistance to earthquake shocks, especially when a weak mortar such as mud is used. In ancient Babylonia and Ur, reeds embedded in asphalt appear to have been used as horizontal reinforcement in brick walls. Vertical steel reinforcement is now specified for brick masonry walls at corners and junctions. Vertical steel at doorjambs and a lintel band are also recommended. The use of bamboo splints or reeds in place of steel in these places should prove beneficial, especially in single-story houses.

"A false ceiling should be tied rigidly to the roof. Plaster on the ceiling should be avoided or kept to minimum thickness. Light roofing materials are advantageous in reducing the inertia force at the top of a building. Bamboo tile, bamboo shingle, and thatch are satisfactory roof coverings in this respect."[9]

How many pounds make a house?

Flexibility is one bamboo feature that helps it survive quakes; another is *weightlessness*. "Gentlemen, how much do your buildings weigh?" asked Bucky Fuller, whose geodesic domes sit more lightly on the earth and so withstand quakes and winds better than conventional urban architecture.



Bamboo dome members.

Bamboo polyhedra: a synergetic mylar Walden in Louisiana, c. 1942.

Fuller built some early bamboo domes with students at the school of engineering in Calcutta, India.[10]

Bamboo polyhedra, Louisiana 1940s.

An architect from Lafayette, Louisiana, Neil Nehrbass, followed Fuller's footprints in the grove, reporting on building and living in bamboo shelters inspired by the crystal shapes in nature.[11] Of the five regular polyhedra that matter finds comfortable, two are collapsible: the cube or "hexahedron," with square faces, and the dodecahedron, with twelve pentagonal faces. Three are rigid, with triangular faces: the tetrahedron, the octahedron, and the icosahedron.

These shapes—known to mathematicians since the time of Plato in 400 B.C.—show that triangulation creates greatest strength with least material; an experiment with straw—or bamboo branches—and string models can prove this fact to anyone's satisfaction.

Nehrbass designed his bamboo polyhedral shelters for low-cost mass shelter in areas of bamboo abundance. He notes that a hacksaw and drill are the only required tools; that structures using *all members* of the *same length* can be constructed without the skills of reading and measuring; that lashing is a skill available in all cultures, with a variety of local materials such as vine, leather, rope, and so on; that the shelters could be mass-produced at grove site, with a line cutting, curing, trimming, sunning, cutting to lengths, drilling, and packaging.

Total weight of a 175-square-foot shelter (roughly 13 feet × 13 feet in a square) including all

framing, skin, ventilation, and door is only 60 pounds, 10 cubic feet in volume. Packaged, this complete shelter can be carried by one person and assembled in four hours without tools on site requiring no foundation but anchored to stakes in winds.

From a harvest of four hundred poles with 1½–1¾ inch basal diameter, Nehrbass cut thirty 10-foot bamboos and built one complete icosahedron, a twenty-sided figure of equilateral triangles. If you cut off the bottom, you're left with ⅚ of an icosahedron, composed of twenty-five equal members. Nehrbass built nine of these, four with 10-foot members, three with 7-foot members, and two with 5-foot members, using the different structures to compare different methods of flooring, skinning, ventilation, and doors.

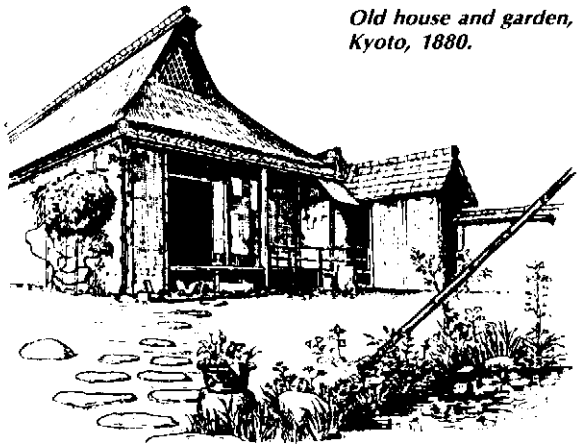
At the hub a rubber ball rode the ends of five poles drilled an inch from the end and lashed with leather to form a firm but flexible joint.

Although Davis in *Shelter After Disaster* (1978) warns against confronting disaster victims with outlandish shapes that might shock them more, the ease and rapidity of construction might warrant using these polyhedras experimentally to test their acceptance and practicality. Demonstration of the form in several Nicaraguan villages inspired interest. Construction as part of a school project or as playground structures might be one way of introducing them to a community. Villagers responded to the idea of their use as kitchens since in many areas a small cookhouse or *cocina* apart from the house is characteristic of rural Latin architecture. Boy Scouts, summer camps, and tropical guerrilla fighters are others who might find the form useful.

Those interested in bamboo polyhedras should be familiar with *Polyhedra: A Visual Approach* and *Introduction to Tensegrity* (1975 and 1976), both by Anthony Pugh (University of California Press, Berkeley, CA 94720).

THE PSYCHOLOGY OF SHELTER

After nine months in the womb, a child—the new package of perfect energy—enters the home, a woven texture of human emotion that swirls between the walls of the house. This swirl is the nest that shapes a consciousness. This emotional microclimate, the family, takes the raw organism of a human being and puts a whole language on two square inches of tongue; dresses the mind, still swaddled in eternity, in local time and custom and routine. The house is the living womb of consciousness, the mold of spirit. Space is the incubator of our patterns of learning and knowing, so architecture is much more than merely the study of physical structure.



Old house and garden, Kyoto, 1880.

Bamboo Walden.

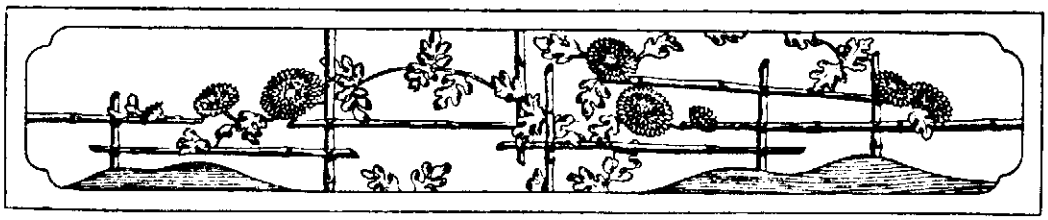
Of all houses in the United States, the White House and Walden are among the most internationally famous. The White House has become the black symbol in the world for the United States as *Macho Negro,* the dark bully of brute force swaggering down history's main street dressed in metal and bombs as if human destiny were a Hollywood western. The president has become an anti-Santa to the whole wide world. Out of his chimney swarm sooty helicopters, dangerous dragons.

Power and force: the longing to build.

Walden is the counterimage of this violent physical force, comparable to the constant juxtaposition in the Old Testament of the power of prophets to the force of kings. Walden represents the quiet rippling, through continents and centuries, of mind power, soul power, naked of excessive ownership. The tiny hut by the small Massachusetts pond, reflected in the careful mind and sometimes sassy Yankee spirit of Thoreau, moved Tolstoy, Gandhi, and other cultural movers far removed from Walden Pond. Thoreau's book reflects that instinctive, precultural longing in us all to shape our own space and shelter, to weave outside our skin some reflection of our mind. Henry's hut is perhaps the most mindfully constructed and recorded event of American architecture. The humility of its scale makes it a feasible norm for everyone and reminds us that the greatness of a person or country is not measured by meters but by motive, not by capacity to dominate but by capacity to meet.

Yankee ashram.

The foundations of Thoreau's cabin were sunk some four thousand years deep in Hindu classics,



The "rama" in the space between door and ceiling was a favorite place for Japanese cabinetmakers and carpenters to display their mastery, often in bamboo only, or in wood and bamboo combined.

which he knew through Emerson. So it isn't surprising that today, a brief century and some later, his construction still feels fairly upright and sound, a house at home in the world. He was building a Yankee version of the Indian ashram or hermit's retreat, pitched just close enough to the careening track of American destiny to shout insights. Looking far back over Thoreau's shoulder, you can make out the mountain sage, familiar from both Chinese philosophy and dinner plates, living close to nature in a place remote enough from humans for a true encounter to occur on the rare occasions when someone actually showed up.

It is not fanciful to choose Thoreau's hut as cousin from American architectural traditions to the teahouse of the East. Both share the same ancestry, both are a small altar to friendship, both offer a model for a tiny, sane, handmade gesture on the edge of a ever more immense and mechanical madness . . . and both are equally dangerous if taken as a complete model to be swallowed in an uncritical gulp. The hazards of excellence were noted by Thoreau himself. "Our manners have become corrupted by communion with the saints," he warns, perhaps aware that he would in time become one of that dangerous—and endangered—species.

Perfection smothers invention.
A "climax" in biology describes a stable community of plants and animals that establishes a balance in time in a given climate and terrain after a long succession of species. In cultures, similar equilibriums occur, perfect embodiments of mind that sum up a prolonged evolution so well they stifle further development. "Man's earliest and most important victories are over his gods," André Gide declares in a long story, "Theseus" devoted in part to this theme.

Escaping the teahouse.
It's possible to approach the East on your knees, but reaching it is more likely with full leg and lung, your whole erect, creative equipment, because the East, most deeply considered, is you. As with all serious quests, the sought turns out to be the seeker. So creative spirits digest traditions to devise and invent, while dummies duplicate. A heavy-handed and exact external imitation of the Japanese teahouse and the ceremony there enacted will be light-years wide of the inner significance and possible present use in Western cultures.

Tradition only comes truly alive when we feel it from inside, sense the bones beneath the historical expression and discover relevant contemporary forms for ourselves. Blind imitation always cheats us of finding our own way. German castles reconstructed on the Hudson in New York, Zen temples carried stone by stone to northern California from Japan—these are whims that only waste precious fossil fuels in senseless transport. And "thou shalt not waste" is a prime commandment in the Zen Eclogue. Just as a scientific experiment must be reenactable by others to be valid, part of the validity of an art form resides in the degree of its availability as a form for others.

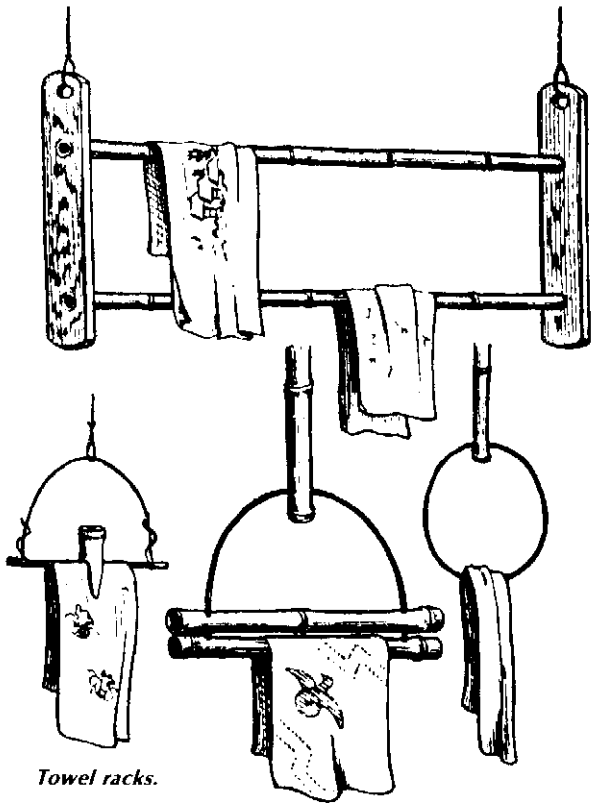
Tight urban dwelling for our times.
The economy and simplicity of the teahouse has proved a possible model for centuries of Japanese. But what would be a true inhabitable teahouse for our time in the West? How can its miniature magnificence serve as a tight model in the space crunch of modern cities, which imposes the good necessity to design our dwelling area as neatly and efficiently as ships? We need a minimal architecture, dweller-made or adapted, with zero waste space. How can the teahouse serve as a suggestive, flexible inspiration in our efforts to roof everyone in a manner that shelters spirit as well as flesh?

Metaphysics of architecture: the Möbius strip.
Contemporary physics in the West has discovered that there are no isolated facts or objects, only "fields" and relationships. Buddhist psychology has always declared there is no "I." Only the crudeness of our observation can persist in maintaining the distinction between this swarm of sensation "inside" our skins that we call "I" and the encompass-

ing universe "outside." The Möbius strip is a Western form that reeks of the East and serves as a useful model to annihilate dualistic categories. If you do not already know the properties of the Möbius strip, cut a piece of paper an inch or so wide from a sheet of paper the length of this page. Twist it once and glue the ends together. Run your finger along one side and then one edge. Although clearly a three-dimensional figure, it has only one side and one edge. The Möbius strip is a physical model of the psychological fact that the other is "maybe us."

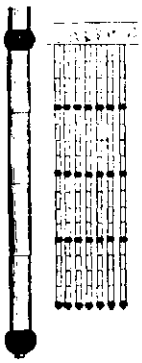
Minimal membrane: leaving the outside in. In Japanese architecture there is an analogous attempt to reduce the distinction between inside and outside. The house is wed to weather and garden, providing a minimal membrane that protects our frail flesh from elements without completely exiling us from leaves and air. Just as we put on shoes rather than try to cover the earth with leather, we can change our attitude rather than the event. In terms of shelter, the Japanese impulse is to put on another sweater rather than turn up the thermostat or build a bigger wall that can't be removed as easily as clothing when fine weather comes. The *shoji,* a sliding screen of paper in a light wooden frame that gives the Japanese home such flexibility in interior partitions, also helps blur the boundary between home and garden. The shoji leaves the roof without fixed wall, opening often onto a platform where the floor continues the room, but without roof, with potted plants further merging homescape and landscape. Many such directions for design can be found tucked into the teahouse. Its diminutive dimensions, natural materials, and attempt at harmony with the surrounding garden—which opens up an otherwise confining scale—are all qualities we can adopt in our shelter designs.

Appropriate nostalgia: Uncle Sam's cabin. It could be argued that nostalgia is one of the great glues of human culture, providing a reassuring continuity in change. In Yucatán, for example, you can admire the Mayan temples built in stone carved to imitate the woven pattern of the bamboo mat walls used to construct temple buildings before Chichén-Itzá and Uxmal lifted their glory above the jungles. Americans like to face cement block walls with knotty pine for the same reasons: The veneer of the old technology is used to cover and lend moral authority to the new. Marshall McLuhan, the Canadian who studied the cultural impact of our communications technologies, remarked that as a technology becomes obsolete it becomes an art form. Bamboo plays that role in the Japanese teahouse for the Japanese. Perhaps a log cabin would be a crude

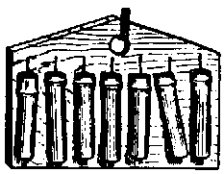


Towel racks.

Kitchen racks can be easily made with a few cuts in larger bamboos—probably moso (Phyllostachys pubescens) *in this sketch by Morse.*



Door curtains are strung from 1-inch culm sections of very thin bamboo, or from waste branch sections of larger species. They make a cheerful clatter when passed through.



Gate rattle. Alarms of bamboo are of many varieties. In fact, the word bamboo, *of Malaysian origin, probably derives from the early custom of throwing green bamboo sections into campfires to explode and frighten off wild animals.*

and partial equivalent for Americans: an architecture reaching deep into our psychic past as a nation, our robust infancy before we put so many layers of history on. As Japan becomes more industrialized and drifts ever further from all the things bamboo stood for, the teahouse becomes more attractive: a modest, rustic, uncluttered, nonmetallic, unmanufactured manageable human scale—everything, in short, the skyscraper in downtown Tokyo isn't.

Leisure shelter: bar bamboo, thatch therapy.
It's interesting that the places built to pass a happy leisure are often so different from the architecture where we live and work. Taverns with bamboo and thatch in the decor hopefully suggest relaxed South Seas isles as far as possible from the busy sidewalk where we are. But even in the tropics, urban cantinas often choose bamboo and indigenous architectural forms—a circular shape and high-pitched palm roof—although expensive zinc, an oven in sunlight and a racket in rain, is chosen as the more stylishly "modern" roofing for homes.

Fifty billion fingers can roof the race.
The universality of nostalgia suggests that instead of trying to stomp it out as a conservative idiocy stuck on the past, fixating on the rearview mirror in place of the road, we should perhaps try to find an appropriate format to replace the fake and cosmetic form it often takes—glue-on plastic veneers of knotty pine. A proper nostalgia could lend emotional energy to our path as we wend our way through inevitable changes, carrying the essence of our relevant past—like Theseus in the labyrinth, leashed gently to both his past—the entrance—and his future—the exit—through Ariadne's weightless thread.

Popular architecture, self-shelter distributing the heavy load of housing on all shoulders, could be the most sturdy and valid nostalgia, a constant in the midst of changes to fasten our future securely to our past. Participation is the key most likely to unlock the door to appropriate world housing, that enormous room for everyone—built on a small, human scale with affection, local renewable resources, and two trained hands.

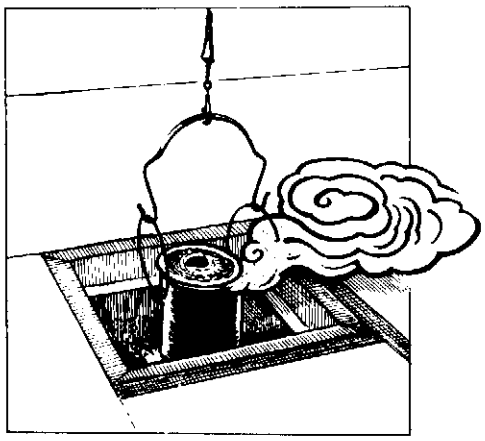
The moral geometry of tea's easy way.
"A social sacrament, a worship of the Imperfect, a tender attempt to accomplish something possible in this impossible thing we know as life." Okakura in his classic *Book of Tea* calls its cult a "moral geometry which defines our sense of proportion to the universe." The island isolation of Japan begat an introspective spirit, a national trait classically embodied in the Zen traditions, which trained one to see the smallness of the great—holding galaxies in the palm of the mind—and the immensity of the diminutive. The whole universe bends attentively above a blooming flower.

> *In one hair pore—ten thousand Buddhalands.*
> *Unnumbered beings there, whom Buddhas teach.*
> *How many hair pores on their face and hands?*
> *Ten thousand Buddhalands in each.*

This attitude implies that our behavior is the most intimate and true altar. The most complete art form is complete people related to others in complete friendship.

Rikyu's art of being in the world.
Rikyu (1521–1591), the great grandfather of Japanese tea, was befriended and later condemned to death by his emperor-patron, the peasant dictator Hideyoshi (1536–1598). Through Rikyu's creative use of the form, multiplied by an early official encouragement, the ideals of the "cult of tea" have influenced Japanese domestic architecture immensely to the present day. The chaste simplicity of Japanese homes that at first strikes foreigners as barren is the stylistic heir of Rikyu's sixteenth century vision of "the art of being in the world."

The tearoom, built to accommodate five people, roughly 10 by 10 feet, was the main structure of a minicomplex that included, attached to it or separate: a side room *(mizuya)* where tea things were washed and arranged and a portico *(machiai)* where guests waited until invited to come along the tea garden path (the *roji*) to the house. The air of refined poverty surrounding the teahouse was partly owing to the fact that everything was scrupu-



lously clean—a virtue also inherited from Zen. "One of the first requisites of a tea master is the knowledge of how to sweep, clean, and wash, for there is an art in cleaning and dusting. A piece of antique metalwork must not be attacked with the unscrupulous zeal of the Dutch housewife."[12]

Zendo to teahouse.

The smallness of the teahouse, 4½ tatami mats or 100 square feet; the unrefined, impermanent materials; the absence of ornament or color, all these qualities contrast strongly not only with Western ideas of architecture but also with the classical Japanese temples and palaces that preceded the immense impact of this tiny shack. The high-class church-and-state official style of fifteenth century Japan was neither small, simple, nor austere. Pillars of wood 2 to 3 feet in diameter and 30 to 40 feet high supported enormous timbers framed for heavy tile. Elaborately decorated canopies, gilded baldachinos, walls full of frescoes and mirrors, statues in residence—the traditional "noble" architecture—was the opposite of everything the teahouse stood for.

The teahouse prototype was not temple or palace, but the Japanese Zen monastery meditation hall. This was a bare dormitory-laboratory for students of mind science, uncluttered and unlike the highly decorated temples of other Buddhist devotional sects, which were crowded with banners, prayer flags, images, children underfoot, and grandmothers in the kitchen cooking the banquet. In the *zendo,* or meditation place, a single flower and Buddha statue lent stark adornment to the altar, which later became the *tokonoma* of Japanese homes, the alcove where the single scroll or artifact is out on temporary display to grace the evening.

Cult of life.

The roji, or path from gatehouse to teahouse, was compared to the first stage of meditation. The keenest patrons of the early teahouses were the harried samurai and government officials who most needed to leave their hurried lives behind; the function of the roji was to sweep the town away. The tea master cleaned the house, the path cleaned the visitors. Twilight in pine needles, rough steppingstones, moss-covered granite lanterns . . . five bamboo culms complete the tranquillity, and the guest bends low to enter the door, no more than 3 feet high, where only a child could pass without bowing. The tea ceremony was the national balance, the cult of life as counterpoint to the cult of war and

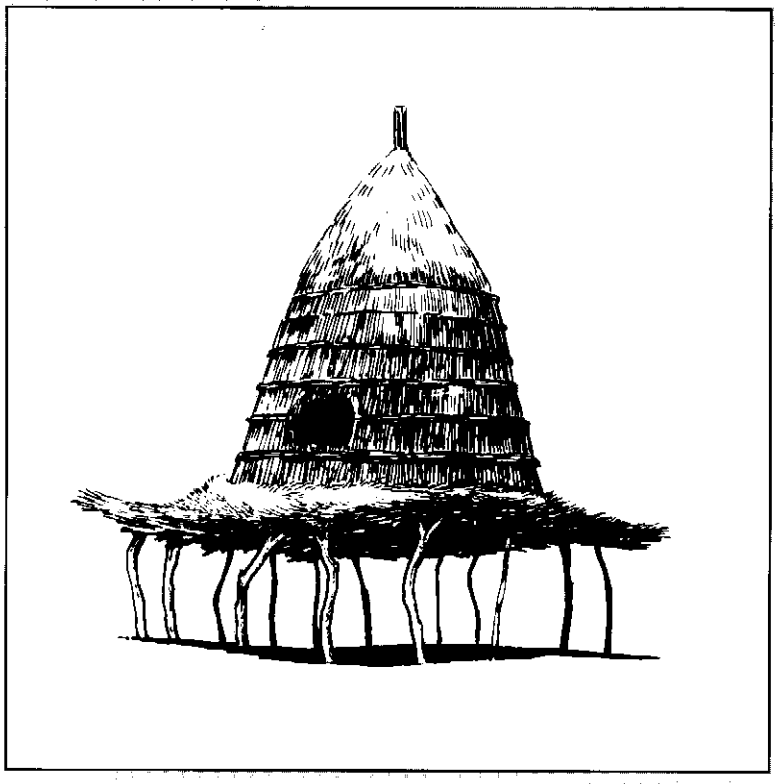
martial arts in the cultural pattern of seventeenth century Japan; so samurai left their swords at the door . . . and bowed again to the picture or flower arrangement in the tokonoma before quietly taking their place. Only the sound of water boiling in the kettle breaks the silence. "The kettle sings well, for pieces of iron are so arranged in the bottom to produce a peculiar melody—the echoes of cataracts muffled by clouds, a distant sea breaking among rocks, rainstorms sweeping through a bamboo forest, or wind in pines on some faraway hill."[13]

CHAPTER 4.

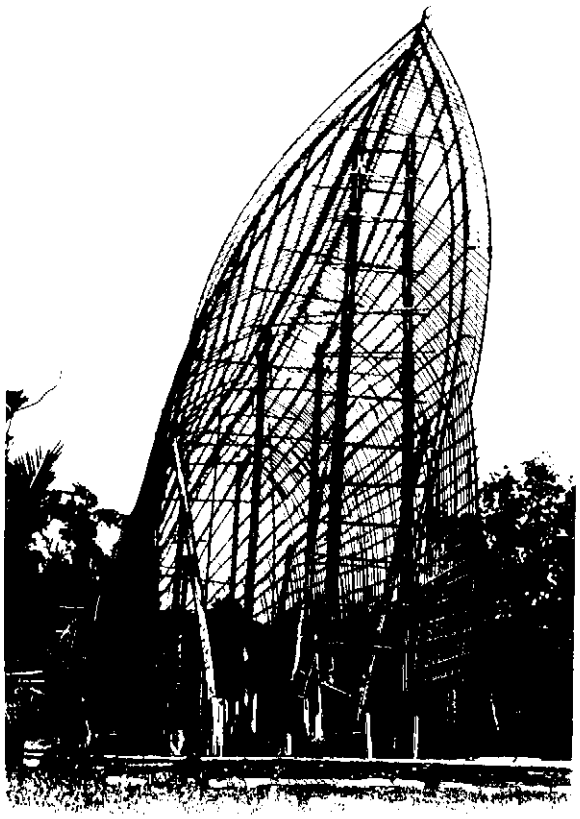
1. Hidalgo 1974: 238–42.
2. The technical data of Narayanamurti's study is extensive, filling ten crammed tables and most of the thirteen pages of his valuable article. Request a copy from Dehra Dun (address, p. 305). M. Singh (1969) also contains relevant but highly technical data. See also "plybamboo" (p. 55) for more how-to details.
3. McClure 1953:7–11.

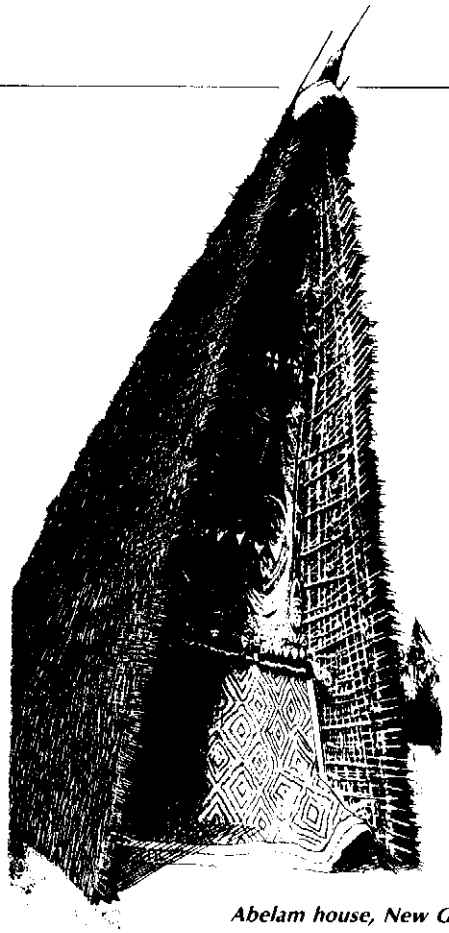
3a. Ibid.: 11; see also Limaye 1952.

4. Varmah 1980:20.
5. Orjala 1980.
6. Squibb 1953, 1957.
7. *New York Times*, May–June 1983. Ernesto Cardenal, the Sandinista minister of culture, claimed in the San Francisco Bay Area in December 1983 that the Nicaraguan armadillos like the new regime.
8. Darrow 1981:662.
9. Narayanamurti 1972:76–8.
10. Hidalgo 1974:234–7.
11. Nehrbass 1942.
12. Okakura 1906:36.
13. Ibid.: 35.



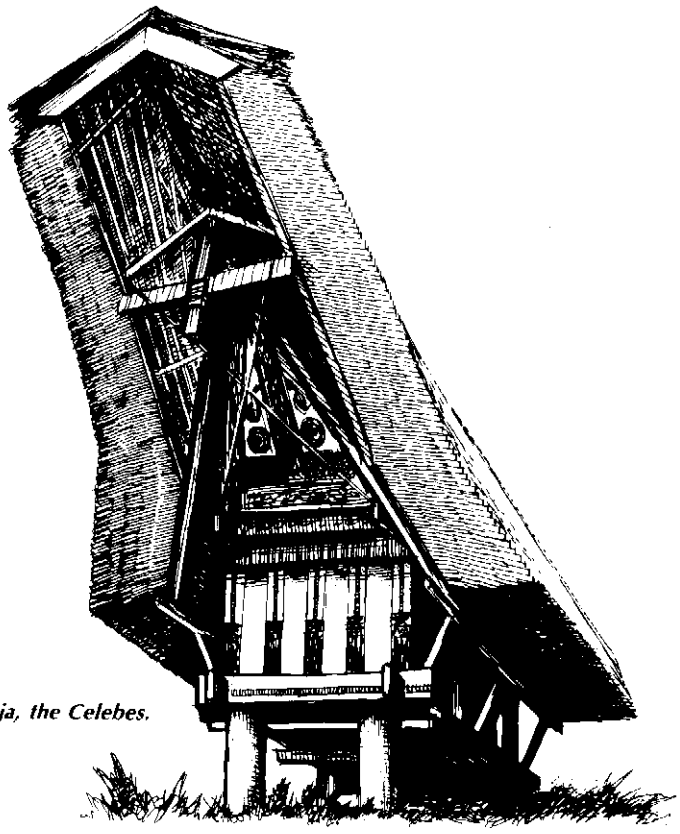
5. POPULAR ARCHITECTURE: A BAMBOO BACKBONE





Abelam house, New Guinea.

"Cathedrals" of bamboo, ceremonial structures providing space for sacred or secular business of the tribe, have until now been mainly male clubhouses. They make use of bamboo's monumental dimensions for shelters that could be models for housing in a crowded world. In the framework of a Dawi, *a men's ceremonial house from the Purari delta region of New Guinea, the gable ends may be 80 feet high.*



Toradja, the Celebes.

The philosophy and know-how of the anonymous builders presents the largest untapped source of architectural inspiration for industrial peoples.

—Rudofsky

Of all the poverties of rich countries, one of the saddest is that the expense of housing makes it ever more difficult for young people to experience building. If we don't grow up building, we will never be fully at home in the act—or in our houses. We will set out too late to ever find our native hand. We will always build "with an accent" if we build at all.

For one countertactic to the architectural illiteracy of "advanced" countries, for rapid diffusion of the experience of self-shelter, we suggest dovetailing people's perennial need for a leakless roof with their chronic longing for a learning road. A College of Wandering and Popular Architecture, with its campus scattered in small holdings among the poor of the world, could earn its crooked Way by its declared homework: the creation of a lightly linked chain of simple shelters by the road where travelers can learn the local methods of building and gardening by direct participation with the neighboring people in these tasks. In return, the travelers can pass on to their hosts appropriate seeds from their own native lands and hints from the growing global inventory of appropriate tricks of human shelter and trades, salvaged from the technological folklore of the whole wide world. The most serious architectural question of our time, virtually unasked in the standard curriculums of schools, is: How can we roof the race in a lean and noble manner? Lean, so there be enough resource for everyone, none standing, shivering, beyond the embrace of the eaves. Noble, so that the dwellings of the peoples of the world cease being a cage and become a class and womb of spirit. How can we design a global building process in which we are all at home again in the intimate art of self-shelter? How can we make villages and towns reflect the ongoing sturdy learning and joyful creation of the housed?

A Pattern Language (Alexander et al.) is one of the few architectural manuals designed both to come to philosophic grips with these questions and to provide people with the means of answering them. It needs to be rewritten and mainly *drawn* for the villagers of the earth, but it is an excellent point of departure for rethinking our conventional notions about world and personal shelter.

To awaken respect for the immense *fact* of popular architecture—still almost invisible in our

"Beehive" house, Kenya.

schools—we present first of all two classic statements in defense of heartchitecture, architecture with heart, blueprints for sane planet shelter by Rudofsky (1964) and Fathy (1973) "condensed for modern readers." Their reflections serve to frame a sketch of *guadua,* the bamboo backbone of popular architecture in Colombia, now threatened with economic extinction. The precarious present position of this resource points out a primary need for any durable popular shelter designs in our crowded time: "Permashelter" for people implies revegetation. Planting is the rational prelude to building. Without replacement of resource, a design for popular architecture is a bird with one wing. Happy rafters aren't possible for long without a pact with the planet to put back what we take.

Nonpedigree architecture.
"Conventional architectural history skips most of the globe, most of the centuries, and all of the common people's nonpedigreed architecture—so unknown we have no term for it—to focus on a who's who of architects who commemorated power and wealth, a brief anthology of buildings of, by, and for the privileged. The building blight of industrial societies also emphasizes the talent of the individual architect, while the serenity of the best architecture in so-called underdeveloped countries is anonymous, a result of communal enterprise, 'not produced by a few intellectuals or specialists, but by the spontaneous and continuing activity of a whole people with a common heritage, acting under a community of experience.' "[1] [Pietro Belluschi]

Town framing: art implies finitude.
"We choose flat, featureless country, erasing flaws in the terrain with bulldozers. Communal architecture is attracted to rugged country and the most complicated configurations of landscape—Machu Pichu, Monte Alban, and the craggy republic of monks on Mount Athos are a few familiar examples of this practice. Security was doubtless one motive for this tendency, but perhaps even more important was the need to define borders. Many old-world towns are still solidly enclosed by moats, lagoons, or walls whose defensive value has long been lost, but which serve to thwart undesirable expansion. Urban derives from *urbs,* the Latin for 'walled town' and suggests that a town which aspires to being a work of art must be as finite as a painting, a book, or a piece of music. Our towns, in contrast, grow unchecked, an architectural eczema which defies all treatment. Ignorant of the duties and privileges of older civilizations, we accept chaos and ugliness as fate. We credit architects and other experts or specialists with exceptional insight into problems of living when most of them are preoccupied, in fact, with problems of business and prestige. We regard the 'art of living,' neither taught nor encouraged among us, as a form of debauch—unaware that its tenets are frugality, cleanliness, and a general respect for creation, not to mention Creation."

Vernacular anticipations of "modern" design.
"The diligence of historians, invariably emphasizing architects and their patrons, has obscured the achievements of anonymous architects, whose good sense in handling practical problems, sometimes transmitted through a hundred generations, left shapes of houses which seem eternally valid, like the shapes of their tools. Many audacious 'primitive' solutions anticipate our cumbersome technology. Many a feature invented in recent years is old hat in vernacular architecture—prefabrication, standardization of building components, flexible and movable structures, floor-heating, air-conditioning, light control, even elevators. Long before modern architects envisioned subterranean towns under the optimistic assumption of protection from future warfare, such towns existed—and still exist, on more than one continent."

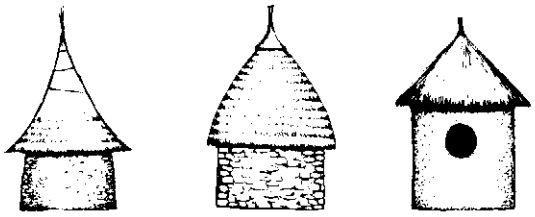
The comforts of inconvenience.
"Ironically, the urban dweller periodically escapes his splendidly appointed lair to seek physical or mental renewal from 'primitive' surroundings: a cabin, a tent, a fishing village or hill town abroad. Despite our mania for mechanical comfort, our relaxation hinges on its very absence, a confession that life in old-world communities is singularly privileged. Instead of hours daily spent commuting, only a flight of stairs may separate one's workshop or study from living quarters. Environments seem to remain most alive for those who shape and preserve them themselves, largely indifferent to 'improvements.'

"Just as toys are no substitute for affection, no technical contrivance can replace 'livability' in homes. So also, the general welfare is not to be subordinated to the pursuit of profit and progress. 'Expecting every new discovery or refinement of existing means to contain the promise of higher value or greater happiness is extremely naive. It is not at all paradoxical to say that a culture may founder on real and tangible progress.' [Huizinga]

"The philosophy and know-how of the anonymous builders presents the largest untapped source of architectural inspiration for industrial peoples. The wisdom of communal architecture goes beyond economic and esthetic considerations, touching the far tougher and increasingly troublesome problem of how to live and let live, how to keep peace with one's neighbor, both in the local and universal sense."[2]

ARCHITECTURE WITH HEART

In *Architecture for the Poor,* Hassan Fathy finds our time a century without signature, eroding traditional architectures in the provinces and replacing them with International Ugly, the global nonstyle, nonsense of world building, nineteen eighty-now.



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Taxonomy of African popular architecture. For the thousand or so tribes of Africa, the style of individual houses (and the format of their customary arrangement in complexes) can be conveniently presented in 32 categories. The drawings by Denyer, below, deserve selective experimental embodiment on one location. Detailed descriptions will be found, by number, at the end of this chapter.

His anatomy of cultural rot led him to a renewed respect for traditions, especially in architecture. There is world relevance in his plea to Egyptian authorities to prop the main beam of traditional family architecture, which he found to be an intimate individuality in responsible dialogue with tradition.

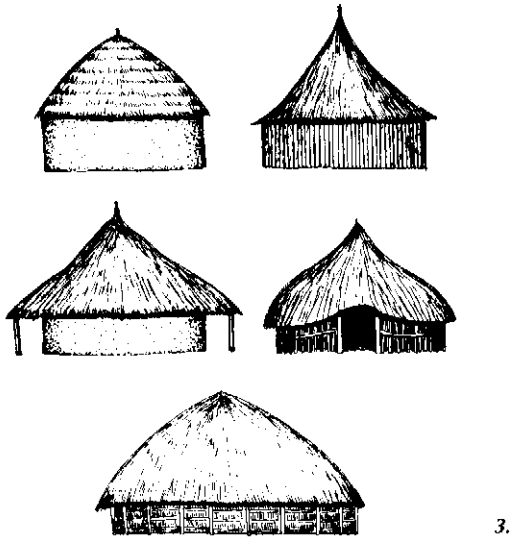
Through a domestic architecture suffused with intense owner participation, deliberately nurturing

2.

local craft traditions of carpenter, mason, furniture builder, stained-glass maker, or whatever local excellence, the whole village becomes a homogeneous work of art, a source of both communal pride and communal livelihood. A scattered constellation of such villages, interrelated but subtly distinct through their faithful reflection of the local genius in woodcarving or other shelter-related art, creates a region with its own unique and authentic cultural character in delicate balance with local materials, climate, and land.*

"Who knows only his Bible, knows not even his Bible," Matthew Arnold warned Victorian bigots. He who knows only bamboo will never notice all the corners where it fits in twentieth century Western cultures. So occasionally, to suggest the cultural soil and site, we are driven to the art of relevant digressions. Fathy's tender analysis of the menaced village, his methods for getting out of the way of the people's own creative energy, his thoughtful defense of both tradition and the individual against the tasteless global soup of mass production and mass consciousness—these qualities make *Architecture for the Poor* an important document in designs for bamboo shelter development everywhere—even though Fathy never mentions bamboo.

Beneath its apparent subject, this book in your hands at this moment is more about those hands, which are always with you, than about bamboo, which is probably less present to your life. Oriental



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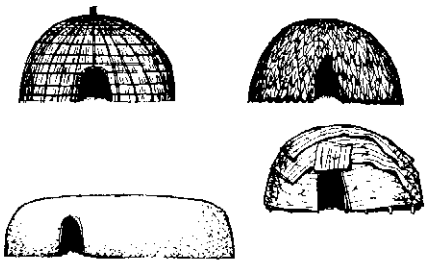
**Editor's note:* Rich inspiration, especially for any Third World housing ministry or architectural activists anywhere, can be found in Denyer (1978), *African Traditional Architecture,* which extends European and Mediterranean studies of vernacular architecture to the thousand or so tribes of tropical Africa. "More architects are turning to vernacular architecture because it obviously satisfied psychological needs far better than most modern suburban settlements."[3] We have drawn on Denyer's "Taxonomy of House Forms," seventy tiny drawings of the wonder of African natural architecture, to punctuate the Egyptian experience of Fathy below. Descriptions of the thirty-two styles drawn are found at the end of this chapter.

traditions of bamboo use happen to be a very instructive example of a durable and creative relation between people and resources. Through centuries of cultural evolution, bamboo remained relevant. Change did not make it obsolete. New conditions revealed new facets of its precious friendliness to human need. It has remained a flexible mate to the quick cunning of human fingers for so long that a deeper and deeper feeling, a more mossy and ma-



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ture mellowness, has had centuries to ripen for the plant in oriental affection. In our time, when three out of five marriages end in divorce, when friendships share roughly the same fatality, when dizzy obsolescence is the design norm, and the same nervous, searching, unbalanced condition prevails everywhere in art, commerce, faith, or fad; in these times, we have much to learn from the steadiness with which the oriental heart woke up beating in unbroken fondness for bamboo for 1,500,000

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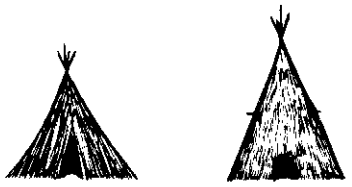
mornings—to cast our mind's eye back only some 4 millennia to, say, 2000 B.C. And those are only the mornings that fall within the small glance of history. We must always remember that, like the 10 percent of the iceberg that's above sea level, history is only the small tip of human reality that thrusts its visible fraction above oblivion into our range of perception. This book, like most, encompasses mere history; but bamboo has been standing beside people far longer than that.

And yet, 25 percent of all people ever alive are alive in our crowded now, so history is more densely present, in a sense, than it has ever been in all history or all prehistory. Human action, love, friction, creation, death—the whole constant upheaval of our natural condition is more everywhere than any humans before us have ever had to encounter.

All cultures, like their comprising members, are mortal. But cultural designs that do not acknowledge this new density of history are doomed to a greater brevity than necessary. We are threatened with shipwreck not by the turbulence of the surrounding ocean, but by conflicts of the crew aboard who are so rocking the boat that even those quietly trying to withdraw from the fray will drown with the belligerents. We are in need indeed of cultural forms less jerky than our hyperlively human consciousness, to steady and ballast the voyage.

The shelter equation: hand + land = house.
Bamboo is one resource that fits this need. Its history contains hints for use of other available materials, sometimes with bamboo, sometimes without. Bamboo's own future history will receive similar



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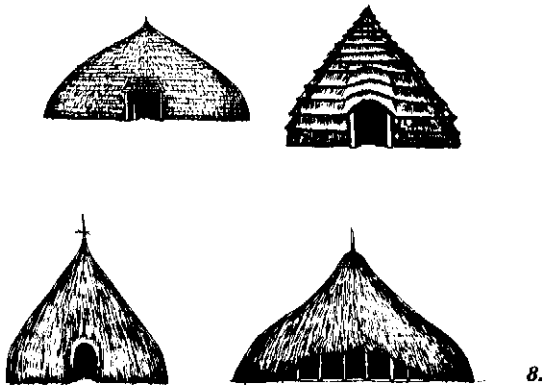
hints, in turn, from many directions, the nearest of which lies, mostly unnoticed, beneath all our feet. Broad distribution is one result of bamboo's vitality, but bamboo isn't as omnipresent, globally, as are people—or mud. But not to get lost in mud either and forget the spectrum of earth's resources, we should keep in mind that the basic equation contains only two constants, human work and human shelter: hand + land = house. The variable, the land and its local building resources, presents a perpetual feast of options where no crude sameness reigns.

Mud.
In the 1940s, Hassan Fathy discovered that the rural housing problems of Egypt were not without exit: They had already been solved by her past. Mud brick vaults, built without scaffolding, were an ancient technique still alive in one region. Fathy set about training masons and securing commissions to explore this viable native reply to the costly and fashionable reinforced concrete, roughly seven times more expensive, in his time and place, and therefore light-years beyond the economy of the poor villager. He proposed owner participation and mud as a truly appropriate architectural reply to Egypt's housing shortage, and after a number of scattered demonstration buildings, he was given the job of building a village for seven thousand people being relocated by the government from the site where, for fifty years, they'd been settled on top of



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an important archaeological dig, plundering antiquities, and melting down priceless gold artifacts thousands of years old. Their path from Old Gourna to New Gourna is a walk rich with instruction.

The government bureaucracy that funded, then frustrated, Fathy's attempts to collaborate with the people in creating sane and beautiful low-cost housing is a familiar dragon that has devoured large pieces of many lives in many countries other than Egypt. His tale is tenderly told and resonates on numerous levels as the best introduction to architecture with heart we could recommend. It has nothing to do with bamboo, but everything to do with the proper spirit, directions, and problems of bamboo development in the poorer countries of the tropics. How to be a Human Being, and remain one while wandering corridors of power trying to pry loose some *piasters* for the poor. How to maintain calm in face of, in spite of, the mindscapes of government officials. These are among the topics that thread Fathy's magic carpet of architectural concern for the world's homeless, which will fly your heart to the mud villages. Be warned that it may be hard to get home again to mesh easily once more with your old assumptions.

The missing signature.

"Every people that has produced an architecture has evolved its own favorite forms, as peculiar to that people as its language, dress, or folklore, beautiful children of a happy marriage between their imagination and the demands of their countryside. No one could mistake the curve of a Persian dome and arch for the curve of a Syrian, Moorish, or Egyptian one. No one can fail to recognize the same curve, the same signature, in dome, and jar and turban from the same district. It follows, too, that no one can look with complacency upon buildings transplanted to an alien environment.

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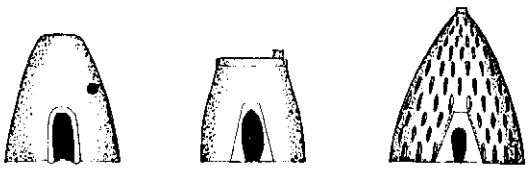
"Yet in modern Egypt there is no indigenous style. The signature is missing: the houses of rich and poor alike are without character, without an Egyptian accent. Style is looked upon as some sort of surface finish that can be applied to any building and even scraped off and changed if necessary. The graduate architect imagines a building can change its style as a man changes clothes. It is not yet understood that real architecture cannot exist except in a living tradition, and that architectural tradition is all but dead in Egypt today. As a direct result of this lack of tradition, our cities and villages are becoming more and more ugly. Every single new building manages to increase the ugliness, every attempted remedy only underlines it more heavily."

How international ugly invades villages.

"On the outskirts of provincial towns, the ugly design is emphasized by shoddy execution. Cramped boxes of assorted sizes in a style copied from poorer quarters of the metropolis, half unfinished yet already falling apart and set at all angles to one another, are stuck up over a shabby wilderness of unmade roads, wire and washing lines hanging over



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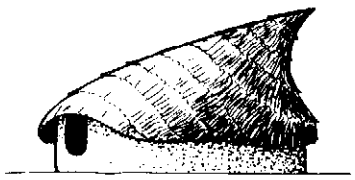
dusty chicken runs. In these nightmare neighborhoods, a craving for show and modernity causes the owner to lavish money on the tawdry decorations of urban houses, while being stingy with living space and denying himself the benefits of real craftsmanship.

"To flatter his clients and persuade them that they are sophisticated and urban, the village mason starts to experiment with styles that he has seen only at second or third hand and with materials that he cannot really handle with understanding. He abandons the sure guide of tradition and, without the science and experience of an architect, tries to produce 'architect's architecture.' What he achieves is buildings with all the defects and none



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of the advantages of the architect's work.

"Thus the work of an architect who designs, say, an apartment house in the poor quarters of Cairo for some stingy speculator, incorporating features of modern design copied from fashionable European work, will filter down over a period of years through the cheap suburbs into the villages, where it will slowly poison the genuine tradition. A scientific examination of this is required to reverse the trend toward bad, ugly, vulgar, and inefficient housing in our villages."[4]

The function of tradition.

"To be alive is to make decisions, and the most subtle decisions are called for when a person makes

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something. Habit may release a man from the need to make many less interesting decisions so that he can concentrate on the important decisions of his art, like a musician scarcely following each finger as it produces a note. Tradition is a social habit releasing the artist from the distracting and inessential so that he can give his whole attention to the vital."[5]

Indulgent innovation = cultural murder.

"Some problems are easy to solve in a few minutes, others need a lifetime; in each case the solution may be the work of one person. Other solutions may require generations, and this is where tradition has a creative role to play. Some traditions—in bread making or brick making, for example—go back to the beginnings of human society and will perhaps exist till its end. Others, though they appeared only recently, were in fact stillborn. Innovation must be a completely thought-out response to change in circumstances and not indulged in for its

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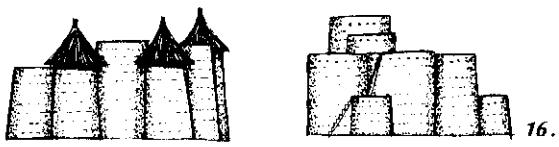
own sake. The individual can be happily relieved of many irrelevant decisions by tradition but will be obliged to make others equally demanding to keep tradition from dying on his hands. In fact, the further a tradition has developed, the more effort each step forward in it costs."[6]

Reactive creation.

"To willfully break a tradition in a basically traditional society like a peasant one is a kind of cultural



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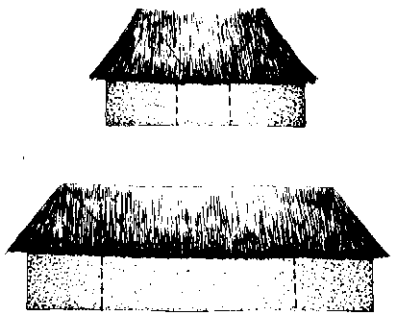
murder. The architect must not suppose tradition will hamper. When the full power of a human imagination is backed by the weight of a living tradition, the resulting work of art is far greater than any that an artist can achieve alone with no tradition to work in or through willfully abandoning tradition. One person's effort can bring about an altogether disproportionate advance, if the person is building on an established tradition. It is rather like adding a single microscopic crystal to a solution that is already supersaturated so that the whole suddenly crystallizes in a spectacular fashion. Yet this artistic crys-



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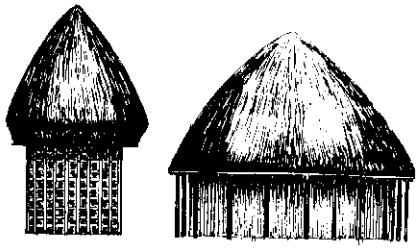
tallization is an act of creative reaction and reactive creation that has to be perpetually renewed.

False synthesis in quest of applause.

"Architecture is still one of the most traditional arts. However hard the architect strains after originality, by far the larger part of his work will be done in some tradition or other. Why then should he despise the tradition of his own country or district; why should he drag alien traditions into an artificial and uncomfortable synthesis; why should he be so rude to earlier architects as to distort and misapply



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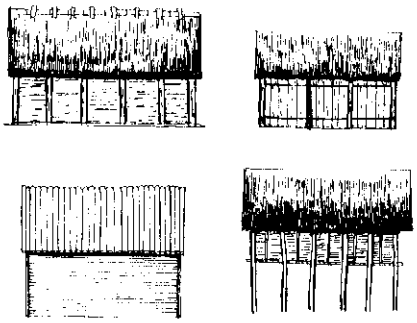
their ideas simply to gratify a selfish appetite for fame?"[7]

Mass solutions, mass culture death.
"If in your dealings with others, you consider them as a mass, abstracting and exploiting the features they have in common, you destroy the unique features of each. The advertiser who plays upon the common weaknesses of humankind, the manufacturer who satisfies the common appetites, the schoolmaster who drills the common reflexes, each in some way kills the soul. That is, each, by overvaluing the common features, crowds out the individual ones. Largely unchallenged, the promoters of sameness have eliminated the tradition of individuality from modern life."[8]

"In medicine no one expects the doctor when dealing with the poor to try to mass-produce operations. Why, then, when a passing infirmity like a sore appendix is honored by careful personal treatment, should a permanent necessity like a family house be accorded any less? If you chop off appendixes by thousands with a machine, your patients will die, and if you push families into rows of identical houses, then something in those families will



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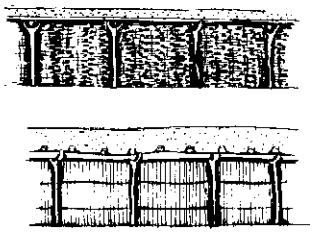

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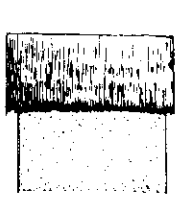
die, especially if they are poor. The people will grow dull and dispirited like their houses, and their imaginations will shrivel. If governments regard people as millions to be shoveled into boxes like loads of gravel—inanimate, passive, always needing things done to them—they will miss the biggest opportunity to save money ever presented.

A creative economy of housing: to create conditions for creating.
"People have minds and hands of their own. A human is an active creature, a source of initiative, and you no more have to build a person a house than you have to build nests for the birds of the air. But the government would still have a very big part to play in a building revival stemming from the individual family. It would have to create the conditions for such a revival to flourish; clearly the conditions do not exist now, or there would be no problem."[9]

Government attitudes and family housing.
"If only governments will change their attitudes towards housing, will remember that a house is the



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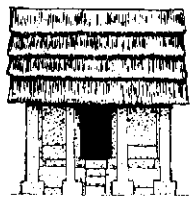

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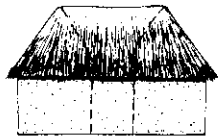

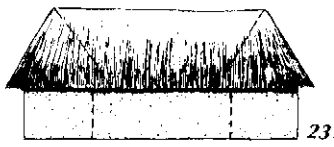

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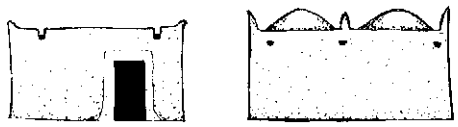
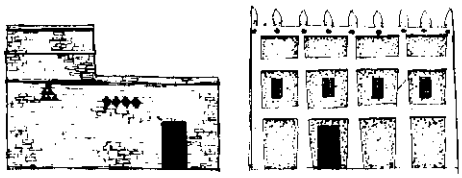
visible symbol of a family's identity, the most important material possession people can ever have, the enduring witness to their existence, its lack one of the most potent causes of civil discontent and conversely its possession one of the most effective guarantees of social stability, then governments will recognize that nothing less will do than the utmost that can be given in thought, care, time, and labor to the making of the family house. They will recognize that one of the greatest services they can render their people is to give each family the chance to build its own individual house, to decide at every





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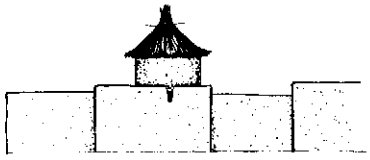

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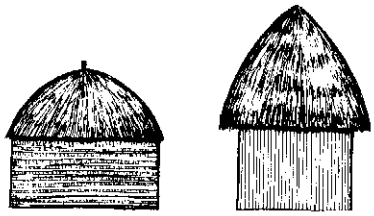

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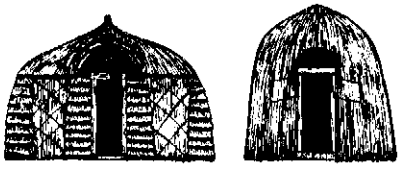

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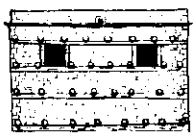

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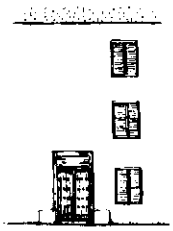

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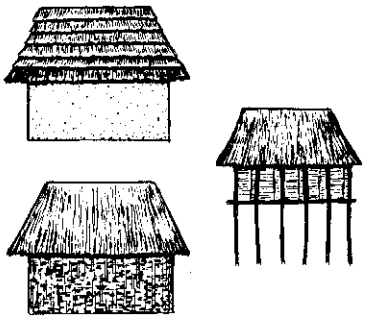

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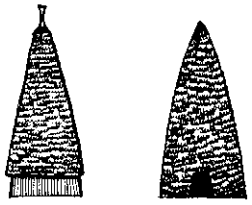

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32.

stage how the house is to be so they feel the finished building is a full expression of their family's personality.

Peru 1959: Christmas birth of a bastard village. "Something happened in Peru that is a lesson to all planners everywhere. In 1959, a hundred thousand people living in the slums of Lima decided to build a complete new suburb for themselves on empty land some way outside the city. Knowing that the authorities would be unsympathetic, they planned the whole operation in secret, like a military maneuver. They divided into four groups, each to have a district in the new suburb, and each with its own leader. They drew up plans, laying out the suburb with roads, squares, schools, and churches. Then on the night of 25 December they marched, carrying materials with them. They reached their target and between 10 P.M. and midnight put up a thousand temporary houses, sited according to their plan, and each quarter had a church. By midnight the authorities had noticed what was going on, and police were rushed out to stop the squatting. Despite this, five thousand people (out of a planned hundred thousand) stayed and still live there at Ciudad de Dios, 10 miles from Lima. If five thousand people can house themselves in one night in a well-laid-out suburb planned by themselves in the teeth of official opposition, what could they do with official encouragement?"[10]

GUADUA ANGUSTIFOLIA

> Guadua is more conspicuous in the local economy of the areas of Colombia where it abounds than is bamboo in any area of the Far East with the possible exception of Java.
> —F. A. McClure[11]

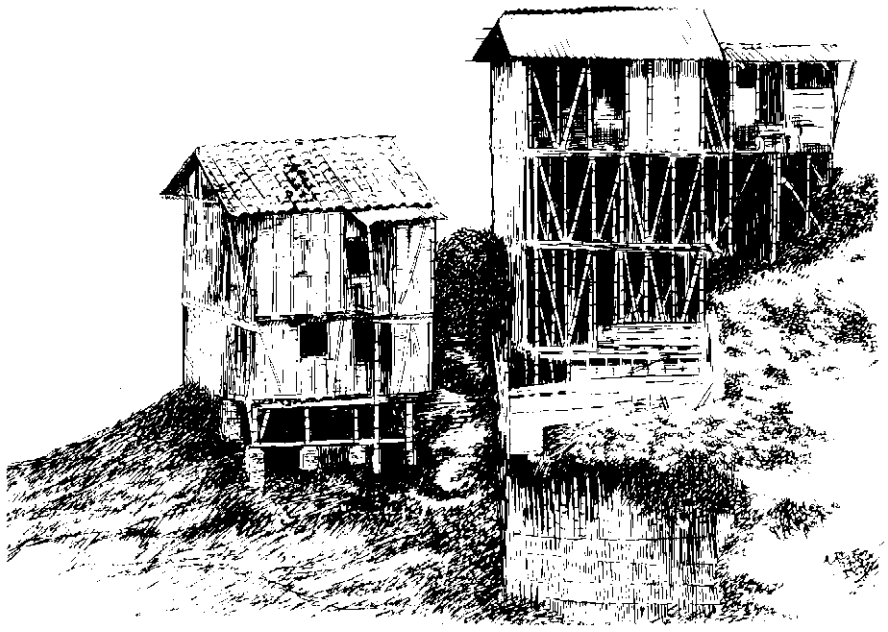
Authentic architecture and misapplied modernity.

> We've always limited the history of architecture to the analysis of a few cultures, represented by the most refined expressions of genius in great religious monuments, palaces, or mansions—while ignoring the roots found everywhere, in the most elemental and humble popular architecture, born spontaneously, profoundly felt, always a clear expression of the spirit of the people.
>
> Although this has been the dominant architecture in our surroundings, we fool ourselves by ignoring it, creating increasingly narrow concepts of beauty and utility. In the name of a misunderstood modernity, we've insisted on applying new techniques, often superficially known, strange to the surroundings, and quite incompatible with the training of the local laborers, who know neither the materials nor the most elementary methods of working them. Workmen adjust slowly to complicated systems and strange ways, comprehensible only after knowing local materials which lend themselves to empirical exploration and appropriate adaptations of new techniques.
>
> Contrary to the neglect lavished on popular bamboo architecture in Colombia, we believe that only a depth study of our own traditions and local materials will make possible the erection of an authentic modern architecture in our midst.
> —Londoño: *La Guadua*

World's most durable, West's largest bamboo. Of seven superbamboos from around the globe selected for special scrutiny by McClure, only *Guadua angustifolia* is native to the Americas.[12] The world's most durable bamboo, and the New World's largest species, it is also blessed with excellent fiber for paper pulp. As skyscraper assistant in scaffolds and poured concrete forms in Colombia and Ecuador, it costs a third as much as wood for these purposes, according to the dean of an architecture school in Guayaquil. It has long been the most common material for low-cost, instant architecture at the city's edge, wherever it grew close or could be transported by raft. Overuse without replanting threatens this multihandy species with virtual economic extinction by the year 2000. With proper care on the part of the people in its regions of growth, guadua could be strategically grown as a hillside crop that also helps hold soil against erosion. It could provide cheap local building material and raw matter for small crafts as well as abundant educational material for schools.

The extended treatment of the species here provides a sample study of bamboo's cultural past, present problems, and possible futures in one region that could be applied to other bamboos in other areas of the West. This sketch of guadua is also intended as half of a diptych—those hinged, twin paintings on ancient altars—which includes the temperate oriental bamboo, moso *(Phyllostachys pubescens),* whose care we examine with care as a similar sample in Chapter 8, pp. 226–231.

From Noah till now. "The Pantagoras tribe which populated the northern part of Caldas, in western Colombia, had a legend that only one Indian survived the Deluge and for many years led a solitary and sad life, until one day God, taking pity on him, turned a bamboo sprout into a woman and gave her to him as his mate. Since then, it is said, the bamboo has given man shelter."



Guadua constructions perch on steep hillsides, and are up to seven stories high. They are usually occupied initially on the street level, with the rest of the structure completed as needed.

Spanish invasion: forts and giant flutes.
"That is how the guadua became a necessary element of Indian survival, especially during the era of Spanish conquest, when they were forced to build guadua forts to protect their families and homes from the greed of the invaders. These forts, built around their villages, were made with a wide rampart using a double wall of guadua stuffed with dirt and rocks, leaving small openings in the lower wall for shooting their arrows and darts. On the upper wall, they would build small temporary bridges covered with guadua mats for throwing rocks or red-hot coals and shooting arrows at the enemy. To scare off the Spanish conquerors, they displayed the heads of their enemies on the upper ends of the guadua canes and drilled holes in some internodes for giant flutes. When the wind blew, the noise would be absolutely terrifying, according to some chroniclers of that era."

Armor and portable stockades.
"The Spanish soldiers not only learned from the Indians how to protect their arms and legs from the arrows by covering them with sections of guadua, but also to use portable stockades of bamboo to protect advances on the forts to set them on fire . . . It has been 400 years since the Spanish conquest. During these four centuries, the guadua has remained an essential element in the socioeconomic development of many parts of western Colombia where this plant grows wild, such as Antioquia, Caldas, Risaralda, and Valle."[13]

Vast virgin groves.
According to Oviedo, the distinguished Spanish chronicler of colonial times *(Historia Natural de Las Indias),* the fertile and well-watered region known as Quindiu, now the Department of Caldas, was once a great forest of *Guadua angustifolia* with scarcely another kind of plant to be seen. The imagination pictures, as a view from the mountain tops in those days, an immense, undulating sea of deli-

cate green, made up of millions upon millions of giant, fernlike plumes of guaduas gently swaying in the breeze; seen from within—a great cathedral with slender rays of sunlight filtering through green windows above.

Colonial uses.
The stems of guadua served a multitude of uses for the early settlers. With such versatile material it was possible, using only a machete, to fashion practically everything necessary for the home from floor to roof, complete with furniture—tables, chairs, beds—even the cradle and utensils for the table. Water was brought to the kitchen in *tarros* of guadua or in aquaducts formed from its hollow stems. Nodes with the branch bases still attached made hooks for hanging the garments in order. Outside, sturdy fences of guadua were constructed as needed to guard crops from wild animals and keep the livestock from straying afield.

Guardian of watersheds.
The land was cleared at great labor, for the guadua, a sturdy and well-anchored plant, resists destruction and decay. Repeated burnings were required to kill the stumps, and even dead they persisted eight to ten years. Corn and other crops were planted in the fertile soil among the stumps, and grasses gradually established themselves, making cultivation more difficult. The grasses in turn supplied pasture for the livestock. More land was cleared, and little by little the *guaduales* (guadua groves) were pushed back from the habitations, the fields became broader, the houses more numerous. It became evident that land the quadua inhabited by preference was the most productive, and so destroying the guaduales became the major concern of the more industrious and ambitious settlers.

As the guaduales were cleared from larger and larger areas, it was discovered that the flow of water in the streams became intermittent: flooding more violently after rains, then subsiding quickly to ever lower levels. And so the idea developed that the guadua is a natural guardian of the water supply. But instead of encouraging its growth on the hillsides where, as we know today, it would do most good, it was kept in the valleys, along the watercourses, while the rolling hills were devoted more and more to pasture, the foundation of the lucrative livestock industry.

Water carriers with guadua canteens.

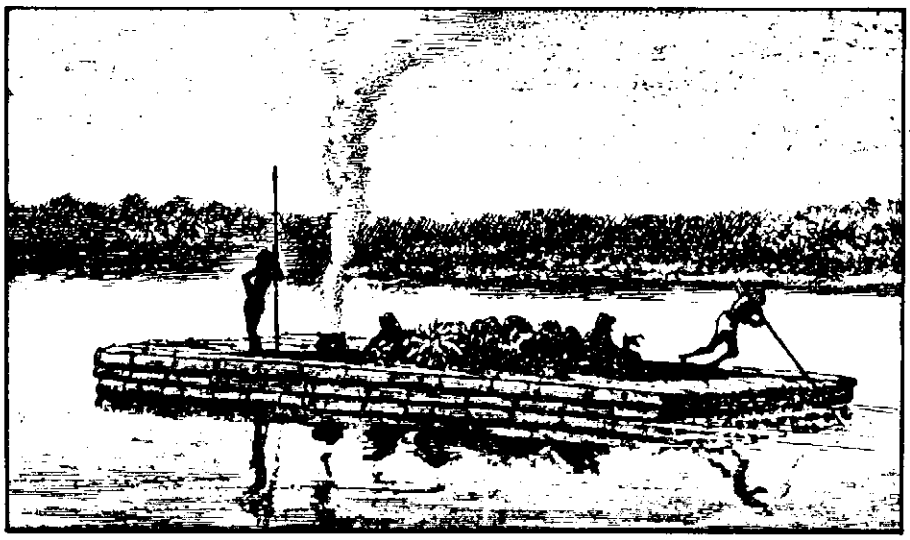
Today, the famous Quindio region is traversed daily by many airplanes, from which it is possible to get a view denied the hardy settlers who traveled laboriously on horseback, in the shadow of the guaduas. Today only the watercourses are still shaded and fringed by the giant green plumes, while the hills are smooth pastures where tens of thousands of cattle roam and graze.

Weed or resource?
The guadua is still the main source of building material for farm structures and fences of the land, but it remains a problem as well—a "weed" that invades the pastures from every margin. In the overall economy, it is considered a problem more than a resource, for constant labor must be expended to keep it from invading and occupying the pastures completely. The market value is little more than the cost of felling and transporting it to the centers of trade. In most areas, guadua for fuel may be had for the labor of cutting it. And in many guaduales the rate of harvesting is so low that great culms die of old age, clog the forest, and decay without being used.

The natural habitat of the guadua appears to be confined chiefly to the area where coffee flourishes. And although some efforts have been made to establish the plant outside its natural area of distribution, the dominant preoccupation has been to limit it as an agricultural measure, so the cultivation and management of guadua plantations is an art as yet undeveloped. One landowner, when encouraged to grow guadua, replied, "I'm not going to cultivate a plant I spent twenty years of my life trying to exterminate."

Where river transport, by rafts, is lacking, costs limit the use of the guadua rather narrowly to the areas where it is produced. Guaduas do reach distant places for construction use, but the price is increased several hundred percent by the outlay for transportation and handling commissions.

Distribution.
Although its abundance has been severely reduced



Guadua rafts in Colombia are used to transport people and goods. In the Orient, bamboo rafts of up to 10,000 culms are built in a series of sections which overlap like tiles on a roof, the front of each miniraft resting on the aft of the raft section ahead.

by clearing to establish pasture lands and cultivated fields, guadua is still the most conspicuous feature of the native vegetation in much of the area. Many people say it "grows like a weed" and that no effort has been made by anyone to establish new groves. The fact that this plant grows spontaneously in all habitats in the region from riverbanks and moist ravines to steep slopes and even the tops of the hills —the most arid sites within its altitudinal range—is ecological evidence that it is "at home" here. It seems likely that this is one of the ancient centers of its distribution, if not the original one. The limits of its present distribution are not fully known. It appears to decrease in abundance as one approaches Manizales from Chinchiná. Manizales, at 2,150 meters (6,987 feet), may represent its altitudinal limit in this area. In Ecuador, the upper limit of this species is generally around 5,000 feet, roughly 1,500 meters.

Wide role in local economy.

Guadua plays a very important part in the local economy of the region. Its culms are found in almost every structure, rural or urban—residences, coffee-drying platforms, coffee and sugar cane mills *(beneficios),* corrals for farm animals, and so on—often to the complete exclusion of all other building materials. Guadua supplies the fence posts and telephone poles as well as the aqueducts that bring water from hillside springs to the rural housewife's kitchen. In fact, guadua is more conspicuous in the local economy of areas in Colombia where it abounds than is bamboo in any area of the Far East, with the possible exception of Japan. The importance of guadua in the local economy is reflected by the criteria by which a *finca* (farm) is judged. It is said that among the first questions asked by a prospective buyer are: "Has it a good water supply?" and "Does it have plenty of guadua?"

Local cultivation lore.

As with bamboo in China, the size and lasting qualities of the culms of guadua in Colombia are said to depend upon the nature of the habitat in which the plant grows. On rich, moist, lowland soils, the culms reach their greatest development in size and thickness of wood; while on less fertile, less moist soils, the culms are smaller in size with thinner wood. The latter, however, are said to give longer service under average conditions. Here, as in other Latin American countries where this and other species of Guadua grow, it is held as self-evident that a definite relation exists between the time of cutting and the durability of the culms. The belief is that culms cut in the increase of the moon *(creciente)* decay promptly and are promptly attacked by bamboo beetles, locally called *gorgoja* (*Dinoderus minutus* and other species known collectively as *"la polilla"* in much of Latin America). Those cut in the decrease of the moon *(menguante)* are considered to be endowed with the fullest degree of durability. (However, see pp. 221–222 on beetle tests in Puerto Rico and Trinidad.)

The idea of utilizing more fully the great resource that guadua offers has occurred to many progressive persons in Colombia, but the obstacles pointed out have prevented the realization of definite plans.

Guadua is a plant ideally suited to the conservation of the soil in those areas where it is native. It grows well on slopes of all gradients, is free from destructive disease and insects, and offers a prod-

uct of importance in the local economy. It is important that guadua's potential be developed.[14]

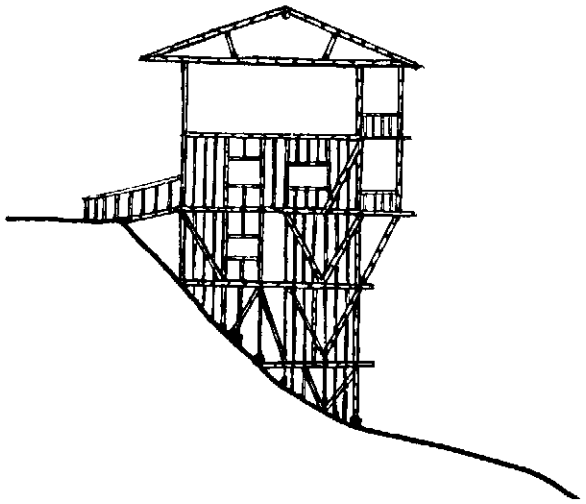
FLEXIBLE SHELTER

Urban planning and the ephemeral family.

"My first interest in guadua was pictorial. These constructions were a good theme for paintings and drawings because of their geometrical structure and the way white houses with splashes of primary color leapt up from an exuberant vegetation. Then the architectural and urban solutions implied in the dwellings began to interest me. Later I was able to compare solutions seen in Caldas with the most modern ideas on the subject and they coincided in a number of ways: in the intention to have dense urban nuclei; to give the street other functions apart from mere space for traffic; to construct in the most mobile, flexible, and economic way, most in accord with our evolving world.

"The use of guadua has lasted until our own time, although it is now being replaced by more durable and expensive materials whose very durability serves to stratify existing inconvenience. They don't permit flexible adjustment to urban, social, or familial changes. Before, everyone used guadua; now its use is marginal, temporary, without proper appreciation of its possibilities. Colombia is a country in process of rapid industrialization, with all the advantages and inconveniences which this implies, particularly with respect to urban sprawl. Our cities are growing uncontrollably, through country people arriving in search of work—or in search of security lost in rural areas during bitter political struggles. Rural villagers crowd into urban slums, and Colombian government agencies in change of such problems invest in high-cost, long-lasting materials out of range of the people's resources.*

"Guadua construction, lasting roughly forty years, corresponds to the cycle of a family's evolution, beginning with a newly married couple; then a few children; then, a few years later, returning to the initial pair. Prices of guadua houses are on a level with the extremely limited means of the inhabitants. The construction is rapid and later changes can be made without great time, cost, or labor. As a rule, they are constructed by the inhabitants with help perhaps from a carpenter but never from engineer, architect, or other professional.



"Light and cheap, easy to change, easy to raise or remove, guadua constructions seem particularly appropriate in our changing urban environment where buildings are knocked down to widen roads, and the city is constantly rearranging itself in an effort to function more smoothly."[15]

Manizales: Bambooville.

Barrio Galan, the bamboo shantytown on the north edge of Manizales, resounds all day with the whack of hammer and hum of saw—an entire community in constant turmoil of construction, almost *breeding* rather than erecting dwarf dwellings built with all the economy of a trim ship; overgrown doll houses by U.S. standards of excess, homes that are homemade with affection and friends and jauntily concluded with a splurge of red paint on the stairway bannister or a bright blue door that swings open easy to the knock of strangers.

How many townpeople in Zonesville, industrialized cultures, have the luxury of building their own homes? Nearly a century and a half ago Henry Thoreau was asking in *Walden* how often we come across people busy with this basic task of raising their own roof. An experienced ornithologist whose word is not to be taken lightly, he maintains that if we all wove our own nests, we would also sing more, like the birds.

"The teeth fall out before the tongue," as the Chinese proverb says: an irony of architecture now in earthquake zones like Manizales is the collapse of "permanent" concrete and steel structures too

**Editor's note:* A by-product of this nonsolution is to erase the still-fresh capacity for self-shelter that new city dwellers bring with them from the countryside. Instead of encouraging and preserving and extending this capacity in the curriculum of the school system, country people are taught to regard their village skills as obsolete and definitely inferior to the International Ugly replacing them. With the eagerness of all immigrants to do as Romans when they get to Rome, they dutifully forget their traditions with haste and embarrassment instead of exploring how they could be dovetailed into urban building needs.

rigid to give, while the "temporary," seemingly insubstantial, bamboo "slums" remain, flimsy and flexible, rolling with the earth ripples.

And then bamboo, after the disaster, helps put the big city downtown back together again—becoming scaffolds, forms, and supports in the poured concrete architecture downtown, where cement floors are suppled and lightened with *esterilla* bamboo boxes: big 2 by 4 by 8 foot cartons that honeycomb the structure and give it more give.

Balloon frame bamboo.

"The topography of western Colombia is often quite steep: as a consequence, houses with one or two floors on the street might have up to seven floors in the rear, depending on the incline of the land. For quake or steep land constructions, guadua is excellent. A light material, it doesn't require heavy foundations, sometimes just rests on big rocks . . ."

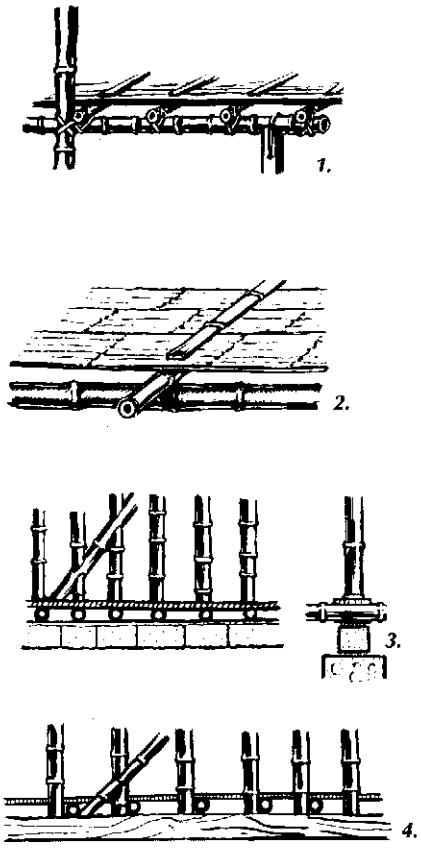
Walls.

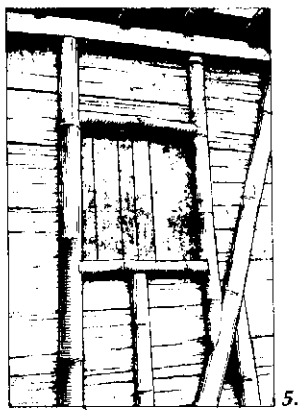
"Walls are formed of guadua poles, 30 cm between centers, with diagonals to add resistance, creating a system similar to American 'balloon frame' construction. A 'cage' quite capable of resisting seismic movements and landslides is thus created, which is rarely seen to collapse completely.

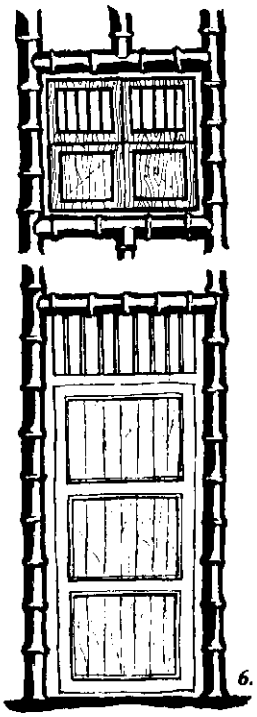
"This structure is covered with opened guadua, flattened out, creating an excellent surface to receive plaster, of horse manure, mud, sand, and cut straw, which makes an air space reducing noise and moderating temperature changes. A solid wall is produced by strips of guadua tied on horizontally, every 15 cm on both sides of frame, the space between then filled with earth and chopped dry hay. Lime is used for the final coat."

Unified streetscapes through wide use of few materials.

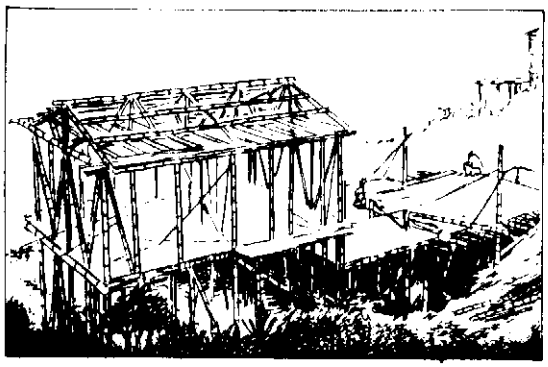
"The general use of a few materials in all buildings regulates dimension and appearance of urban complexes, increasing homogeneity, so absent in conglomerate modern urban architecture. Walls, covered with lime, serve as a neutral background for colors used with great freedom of combination and imagination in doors, windows, and woodwork generally, individualizing each house without de-







Guadua construction, Colombia. 1. Flooring. 2. Detail. 3, 4. Foundation, framing. 5. Windows greatly diminish the load-bearing capacity of the walls. Unplastered esterilla *(bamboo board) provides a thousand tiny horizontal windows, slivers of light which give a wonderful glow inside. 6. Window and door.*



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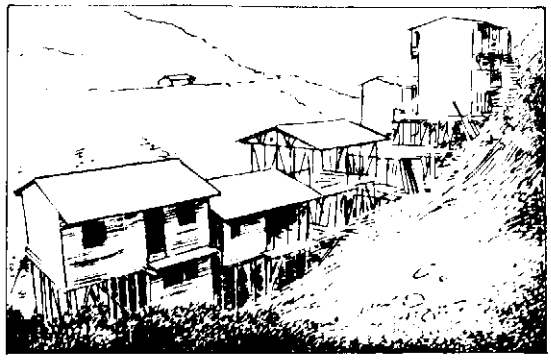

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Guadua houses under construction in Manizales, Colombia, by CRAMSA, a local corporation dedicated to appropriate technology.

tracting from the effect of the whole.

"The fences—made with many weaves of guadua—complete the scene, delicately indicating boundaries without breaking the flow of outside spaces as stone walls would."[16]

Modern times: guadua high rise.

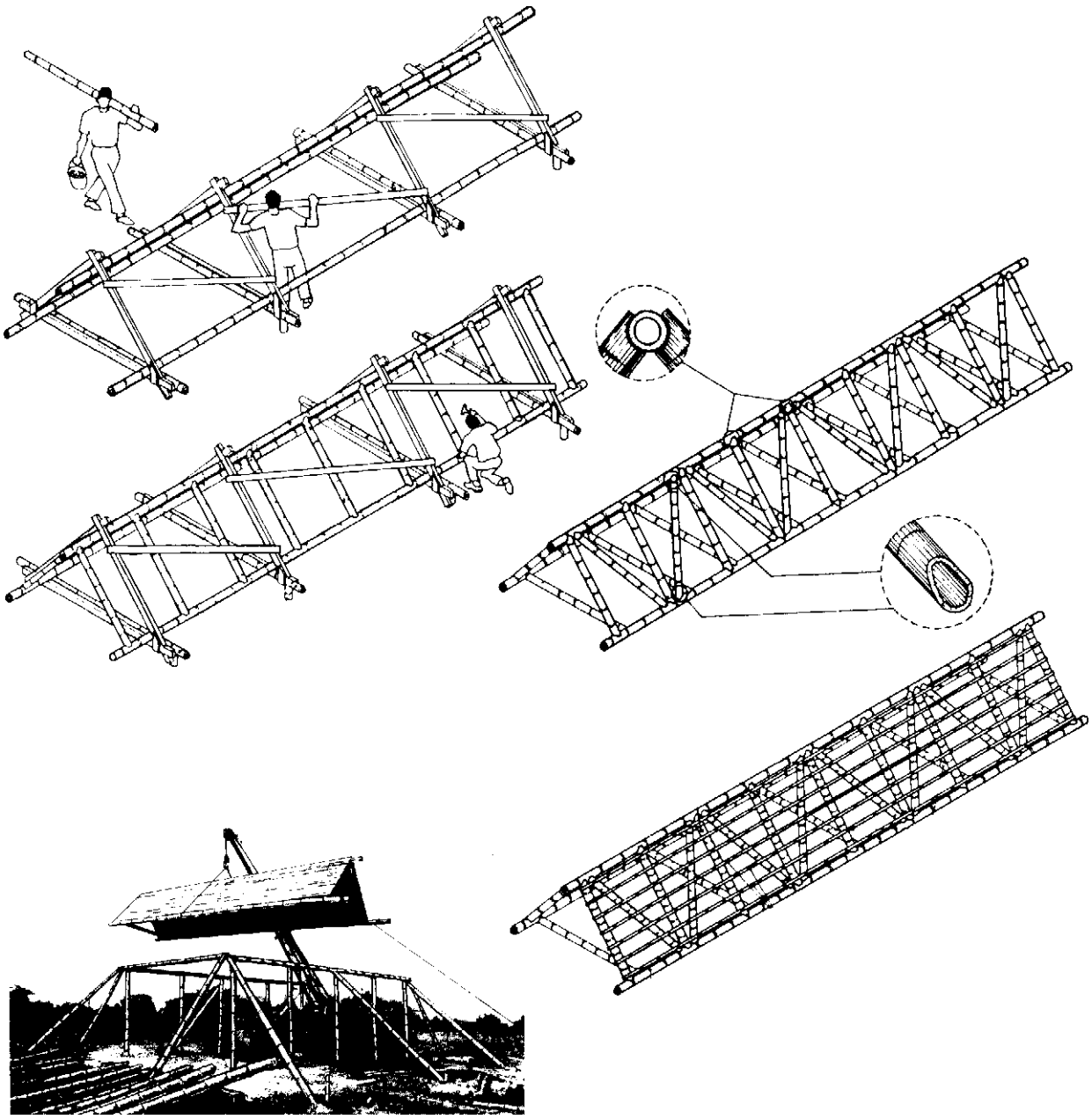
"Taking advantage of guadua's qualities, the campesinos of Caldas have developed excellent construction techniques suitable not only to erect large structures like gigantic plants used by coffee growers to dry and store coffee, but more importantly, in the construction of urban dwellings. The best examples of the latter can be found in Manizales, the cradle of guadua architecture in Colombia, where magnificent homes built half a century ago have been only recently modernized by changing their facade to mortar cement, more in keeping with the new brick and concrete buildings that have been slowly replacing them.

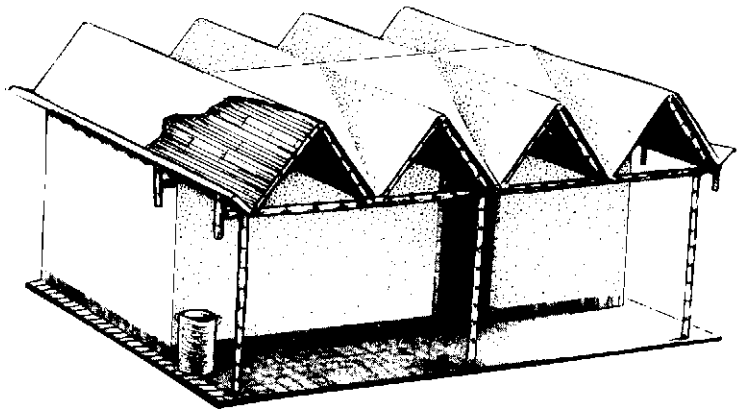
"The arrival of the concrete era that gave such impetus to the construction industry in Colombia also brought new ways to use guadua: temporary retaining walls under protecting eaves and in the construction of secondary frames, used to support the slabs of the building while the concrete is cast and set. Large boxes or cases made of guadua boards are used to reduce the cost and weight of concrete slabs. They are placed over wooden or guadua frames between the spaces that separate the steel framework which reinforces the slabs.

"Once these boxes are in place, casting slabs can begin, by filling spaces between them. At the same time, the cases are covered with a layer of cement that will form a thin slab and become the ceiling foundation. Later, this will be covered below by a ceiling often made of braided guadua panels or *esterilla*—guadua boards—covered with mortar. After building construction, guadua scaffolds are built to work on the facade."

The death of bamboo.

"Guadua has been the cheapest and most readily available construction material, widely used by the poor in building their homes. Some 6 million Colombians in town and country—mostly in marginal areas of big cities—are living in homes partially or totally built with guadua. Many of these neighborhoods are on extremely steep terrain where, in order to build along the road, it's often necessary on the downhill side to build a 5–8 story guadua structure supported on rocks placed directly on the ground. Although in these areas some





Triangular sections of a crinkle roof guadua structure are easily assembled on the ground and lifted into location by crane. A pulley on a branch overhanging the site could do as well. The finished structure can serve many community roles from school to clinic, and can easily be extended as needed.

A few thousand miles north of its natural distribution,* Guadua angustifolia *displays its characteristic squat nodes in the St. Louis, Missouri, Climatron in Tower Grove Park.

excellent guadua structural systems were developed, it was here also that the common aversion to guadua was born, stemming from misuse people made of it in huts constructed with little technical know-how or esthetic consideration—and with unappealing results that have made guadua synonymous with impoverished squalor.*

"There is a complete lack of interest in guadua cultivation, as well, and large groves are leveled off for coffee, sugar cane, and other more profitable crops—or to satisfy the growing demand of the construction industry which presently uses thousands of tons of guadua, apart from what is used for low-cost housing and other purposes. *As a result of intense exploitation, we foresee guadua's commercial extinction in Colombia before the end of this century.*

"Has anyone considered what will happen once the guadua is gone? What material will the campesinos and the poor people use to build their homes? There is no doubt that they will have to resort to agricultural and industrial refuse. The rural areas and the poor urban neighborhoods that once used guadua will then be a terrible spectacle of poverty, full of huts built with left-over scrapwood, cardboard, and metal sheets. Then, too late, through its absence, the real value of guadua will be seen."[17]

Extinction rhythms: antiextinction.

Extinction of species is a work-in-progress of humanity now.[18] Biologists used to say that extinction was happening at fifty times its preindustrial pace: now there are estimates that between 500,000 to 2 million species of plants and animals will disappear by the year 2000 with our assistance . . . roughly 70 a day at a conservative count, or one species every 20 minutes. That's the rent the rest of the planet has to pay for being neighbors to our race. What tactics can we adopt between now and the time that governments decide that this is a ruinous rate which, even from the perspective of successful "exploitation" of nature, we can't afford?

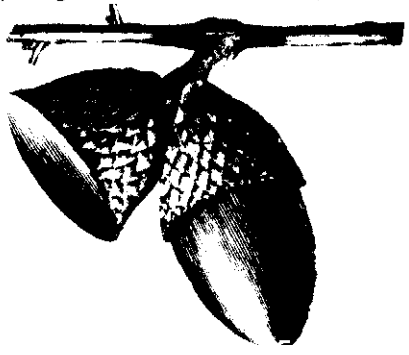
Life is a thin, breathing blanket on the earth in which the interdependent weave of species is not always obvious until we begin to unravel the fabric. "Useful to people" is a very crude criterion to apply, tainted by the same homocentricity that accelerates extinction around us to begin with. But guadua is a plant of major importance not only to us, but also to the biosphere. Defending its right to be here is an act of ecological as well as economic importance. The time may come when *Colombianos* will lament its passing as deeply as the plains Indians in the United States grieve the extinction of the buffalo.

"Regroving" the areas of guadua's distribution is high on the list of bamboo tasks in the West. International agencies such as the United Nations should assume responsibility for this and other bamboo errands of critical urgency—until that day when we have a United Creatures with ambassadors from the land of bamboo and other species to make people more conscious of their duties to the rest of creation here with us, with equal right to life, liberty, and the pursuit of sunlight.

The man who loved trees.

In 1913 a young Frenchman walking in a remote and barren area of southeastern France stumbled across a widowed shepherd who was dedicating his still-vigorous energies—he was then fifty-five—to planting one hundred acorns each day in a belief that the region, devastated by charcoal makers and others, needed trees. Elzeard Bouffier had been planting since 1910, and of his 100,000 acorns, 20,000 had sprouted, of which he expected 10,000 to survive whatever rats or unlucky weather might cast against them.

The young Frenchman, Jean Giono, was soon drafted into five years of World War I and all but forgot Bouffier, whose work he had "considered a hobby, a stamp collection." But in 1920 Jean returned and found Elzeard tending bees instead of sheep which would threaten his shoulder-high stands of young beech and birch trees, "delicate as



*Editor's note: Harvest and curing methods, critical for longevity of building or basket, are little known. See pp. xx–xx.

Guadua flower.

young girls," that he had planted along with his acorns.

"I had seen too many men die during those five years not to imagine easily that Elzeard Bouffier was dead, especially since at twenty, one regards men of fifty as old men with nothing left to do but die. He was not dead. As a matter of fact, he was extremely spry . . . The oaks of 1910 were then ten years old and taller than either of us. It was an impressive spectacle. I was literally speechless and, as he did not talk, we spent the whole day walking in silence through his forest."

Bouffier's hobby was at that point 11 kilometers long by 3 wide. "When you remember that all this had sprung from the hands and soul of this one man, without technical resources, you understand that people can be as effectual as God in realms other than destruction." In 1913, Jean had found dry, desolate villages, "five or six houses, roofless ruins like an old wasps' nest, gnawed by rain, the tiny chapel with its crumbling steeple . . . And over the carcasses of the houses, the wind growled with unendurable ferocity, like a lion disturbed at its meal." By 1920, a grayish mist covered the mountaintops like a carpet when seen from a distance, and close up there was the sound of running water: "Creation seemed to come about in a sort of chain reaction." As we went back towards the village, I saw water flowing in brooks dry since the memory of man. Some of the dreary villages had been built on sites of Roman settlements, traces of which still remained. Archaeologists, exploring there, found fishhooks where, in the twentieth century, cisterns were needed to assure a small supply of water."

At seventy-five in 1934, Elzeard built a stone cabin about 12 kilometers from his original cottage to begin a new forest of beech. By 1935, when Jean visited again, the desert of twenty years earlier was covered with trees 20 to 25 feet tall. "Peaceful, regular toil, the vigorous mountain air, frugality and, above all, serenity in the spirit, had endowed this old man with awe-inspiring health. He was one of God's athletes. I wondered how many more acres he was going to cover with trees."

A friend of Jean's in the French forest service assigned three rangers to guard the forests, "and so terrorized them that they remained proof against all the bottles of wine the charcoal burners could offer." In World War II, cars in France were operating on *gazogenes,* wood-burning generators, and cutting was tried on the oaks of 1910 but was abandoned as uneconomical due to distance. Elzeard was unaware of the attempt and the failure, busy planting 30 kilometers away, ignoring the second world war as he had ignored the first.

Jean visited his friend for the last time in 1945, when Elzeard was eighty-seven. There was now bus service between the Durance Valley and the mountains, and only the name of a village convinced him he was traveling the same region he had first traversed on foot in 1913. "The bus put me down at Vergons. In 1913 this hamlet of ten or twelve houses had three inhabitants, savage creatures, hating one another, living by trapping game, all about them nettles feeding on the remains of abandoned houses. Their condition had been beyond hope, nothing to await but death—a situation which rarely disposes to virtue.

"Everything was changed. Even the air. Instead of the harsh dry winds that used to attack me, a gentle breeze was blowing, laden with scents. A sound like water came from the mountains; it was the wind in the forest. Most amazing of all, I heard the actual sound of water falling into a pool. I saw that a fountain had been built, that it flowed freely, and—what touched me most—that someone had planted a linden beside it that must have been four years old, already in full leaf, the incontestable symbol of resurrection.

"Besides, Vergons bore evidence of labor at the sort of undertaking for which hope is required.

Hope, then, had returned. Ruins had been cleared away, dilapidated walls torn down, and five houses restored. Now there were twenty-eight inhabitants, four of them young married couples. The new houses, freshly painted, were surrounded by gardens where vegetables and flowers grew in orderly confusion, cabbages and roses, leeks and snapdragons, celery and anemones. It was now a village where one would like to live . . . On the lower slopes of the mountain I saw little fields of barley and rye; deep in that narrow valley, the meadows were turning green."

Two years later, in 1947, Elzeard Bouffier died as peacefully as he had lived, in the hospice at Banon. In 1953, forty years after his initial visit, Jean returned again to the region, which he found glowing with health. "On the site of the ruins I had seen in 1913 now stand neat farms, cleanly plastered. Old streams, fed by rains and snows the forest conserves, are flowing again. Their waters have been channeled and on each farm, in groves of maples, fountain pools overflow on to carpets of fresh mint. Little by little the villages have been rebuilt. People from the plains, where land is costly, have settled here, bringing youth, motion, the spirit of adventure. Along the roads you meet hearty men and women, boys and girls who understand laughter and have recovered a taste for picnics. Counting the former population, unrecognizable now that they live in comfort, more than 10,000 people owe their happiness to Elzeard Bouffier."[19]

Minimal ecoethic.

There is a hidden irony in much high-tech development that is exemplified in a computer's use of paper, which is horrendous and immense. In poorer countries, waste computer paper is just replacing banana leaves as the cheapest way to wrap a roadside restaurant meal, which is a rough index of how much paper pulp our slim machines devour. The evolution from pen to typewriter to Xerox and computer printouts can seem a further and further leap from our original wilderness; but, in fact, the more sophisticated and high-tech we become, the more our communication system and general cultural style tends to go back to trees and erase them. The more artificial and humanized our environment, the more apparently distant from nature, the more it in fact depends on a natural balance already overburdened by our extravagant use.

A minimal ecoethic for our time would be for people to replace at least renewable resources they personally consume. Tree planting is the most tangible, ceremonial, and appealing activity through which to move culturally in this mending direction. Our schools and mass media should work toward creating popular awareness of the importance of revegetating to keep pace with human use and to correct former abuse. Reestablishing forest communities of all sorts, including bamboo where relevant, will cure planet and people in a single act.

Recording our thoughts about the matter knocks still more forest down. If it does not inspire planting, the gross effect of this book will be a balder globe.

Planet pact for happy rafters.

Now nest beside this ancient tree,
let these woods be good to me.
In return, I vow to make
twice the lumber that I take
and plant for every daughter and each son
a tree each time our earth has run
its journey once again around its sun.

Whatever dryads dwell within these trees,
or hidden wood nymphs, braided with the breeze,
gnomes tunneling beneath the forest floor
or elves and brownies dozing near my door—
this treaty is directed, by its scribe,
to all earth spirits, of whatever tribe:

Grant my get my vegetating style,
dirt on their knees and taste for toil,
that I may leave a planet yet
more leafed and handsome than I met,
less faked, less driven, less afraid,
facades and faces looking more homemade
when what was gardener a while
joins again the garden soil
and these bones, at length, are laid
their length beneath a greener shade.

A Taxonomy of Housing: **Notes on structures and locations.**

1. Round plan, free-standing; diameter less than height; walled with mud and/or stone; often with stone foundations; thatched roof (conical or trumpet-shaped); arranged in clusters of buildings, usually on the ring pattern, with buildings part of enclosing wall or fence. (Sudan, Tanzania, Nigeria, Cameroon, Mali, Senegal, Guinea, Togo, Benin, Central African Republic.)

2. Round plan, free-standing; diameter approximately equal to height; roof of poles leaning against central framework; poles sometimes encased in dry stone work at base; thatching of grass or turf. (Ethiopia, Tanzania.)

3. Round plan, free-standing; diameter equal to or greater than height; walls of mud and/or wattle, bamboo or palm fronds; thatched conical roof (convex or concave profile); often with verandah full or part way round; arranged in clusters of buildings within surrounding fence, hedge, or wall. (Kenya, Zaïre, Nigeria, Guinea, Cameroon, Tanzania, Liberia, South Africa, Ethiopia, Zambia, Ghana, Sudan, Mali, Senegal, Ivory Coast, Sierra Leone.)

4. Round, oval, or rectangular plan with hemispherical or lozenge-shaped profile; basic framework of hoops; covering of skins, mats and/or thatch of grass, leaves or mud over brushwood; can usually be dismantled; often found in association with cattle kraals; usually arranged symmetrically. (Tanzania, Kenya, Cameroon, Zaïre, Namibia, South Africa Swaziland, Chad, Nigeria, Somali Rep., Ethiopia, Niger, Mali, Lesotho.)

5. Rectangular plan, free-standing; framework of one to four parallel arches strengthened by horizontal cross-pieces resting at ends on poles between forked posts; covering of plaited mats; very often used as portable tent; large version sometimes immobile. (Niger.)

6. Rectangular plan tent; framework of two to four rows of parallel forked sticks surmounted by horizontal cross-pieces; occasionally arches instead of middle sets of poles; covering of skins or blankets under tension. (Niger, Sudan, Ethiopia, Somali Rep.)

7. Round plan, free-standing; conical roof and no walls; framework of straight sticks (guinea-corn stalks, bamboo); sometimes thatched. (Nigeria, Tanzania, Sudan, Ethiopia.)

8. Round plan, free-standing; framework of flexible poles embedded in ground at base and tied at top under tension; known as "beehive" type; usually slightly convex profile; thatch sometimes of banana leaves but more usually of grass or reeds, either stepped or plain; sometimes low perimeter wall inside building; sometimes central support; often divided internally by partitions; same design as house; often with porch. (Sudan, Tanzania, Ruanda, Uganda, Nigeria, Chad, Niger, Ethiopia, Kenya.)

9. Round plan, free-standing; two storeys high; walls of roughly dressed stone set in mud mortar; wooden lattice windows; drip course between each story; slightly domed mud and pole ceiling, thatched roof. (Ethiopia.)

10. Round plan, free-standing; two storeys high; walls of small round boulders set in mud mortar; second storey reached by external stone staircase; within, walled courtyard with two-storey entrance porch; thatched roof. (Ethiopia.)

11. Round plan, free-standing; flat roof; walls of mud or mud and straw; flat roof of poles and mud and straw; found in tight clusters, usually built into surrounding wall; painted and incised decoration on walls common. (Granaries often had thatched covers.) (Mali, Upper Volta, Ghana.)

12. Round plan, free-standing; "shell" mud roof and no walls; slightly convex profile; sometimes embossed patterns on exterior; arranged in clusters within surrounding wall. (Cameroon, Ghana, Chad.)

13. Oval plan, free-standing; asymmetrical peaked thatched roof supported by conical mud pillar and mud arch; walls of mud and wattle. (Nigeria.)

14. Oval plan, free-standing; mud and/or wattle walls; thatched saddleback roof with semiconical ends; sometimes on stilts. (Liberia, Guinea Bissau, Senegal, Tanzania: coastal areas and lake shores; Ivory Coast.)

15. Round or oval plan, free-standing; corbelled stone construction; untrimmed sandstone blocks, doleritic boulders or trimmed doleritic slabs. (Lesotho, Botswana, South Africa.)

16. Round plan: one, two or three storeys in height; built coalescing to form "tower" houses; walls of puddled mud; flat roof and upper floors of poles, straw and mud. (Upper Volta, Benin, Mali.)

17. Crown plan (concentric circles), free-standing; central court or impluvium; mud walls; thatched saddleback roof. (Senegal, Guinea Bissau, Ivory Coast.)

18. Square plan, free-standing; conical roof; walls of mud or mud and palm fronds; thatched roof of grass or reeds. (Cameroon, Nigeria.)

19. Rectangular plan, sometimes free-standing, thatched saddleback or lean-to roof; walls of planks, bamboo, cane, matting or cane and matting; walls sometimes plastered internally; roof thatch of palm leaf mats, reeds, bark, palm fronds, sometimes on stilts. (Tanzania, Nigeria, Cameroon.)

20. Rectangular plan; often arranged contiguously around a central square open kraal; walls of wattle or stone and mud; flat or wagon-shaped mud and wattle roof supported on forked uprights just outside walls or on walls; can be known as "tembe" style. (Tanzania, Uganda, Ethiopia.)

21. Rectangular plan, free-standing; thatched saddleback roof; buildings often arranged facing across a small court with some of the sides facing court open or pillared; walls puddled mud or wattle framework plastered over; relief murals common form of decoration. (Nigeria, Ghana, Togo, Benin, Ivory Coast.)

22. Rectangular plan; thatched saddleback roof; units built round court or impluvium having continuous roof; walls of puddled mud or mud and wattle; sides facing court or impluvium sometimes open or pillared. (Nigeria.)

23. Rectangular plan; mud brick walls; flat or vaulted mud roof reinforced with wood or palm fronds; sometimes two-storeyed; buildings arranged within walled courtyards, sometimes forming part of courtyard wall. (Nigeria, Mali, Upper Volta, Mauritania.)

24. Rectangular plan units; one storey high but built coalescing and on top of one another; mud brick or puddled mud walls; flat mud roof reinforced with wood and palm fronds; sometimes found with style 3 built on top. (Ivory Coast, Mali, Upper Volta, Ghana.)

25. Square plan; free-standing; walls of poles or palm fronds and mud; hipped roof thatched with grass or reeds. (Zambia, Zaïre, Cameroon.)

26. Square plan; free-standing; thatched hipped roof framework of flexible poles embedded in ground at base and tied at apex under tension; slightly convex profile; thatch of grass; often with elaborately carved door frames. (Zaïre, Angola.)

27. Rectangular plan, free-standing; walls of roughly dressed stone set in mud mortar; reinforced with horizontal wooden beams and short round cross-pieces; flat roof of mud and poles. (Ethiopia.)

28. Rectangular plan, free-standing, with stone rubble and cement walls; thatched roof multistorey; often with elaborately carved wooden doors. (Tanzania, Kenya.)

29. Rectangular plan, free-standing; hipped roof; thatch of palm leaf mats sometimes with two long sides lapped over other two; walls of wattle and mud; sometimes with carved wooden door posts; sometimes on stilts. (Kenya, Tanzania, Nigeria, Benin Rep.: coastal areas; Zaïre: lake shores.)

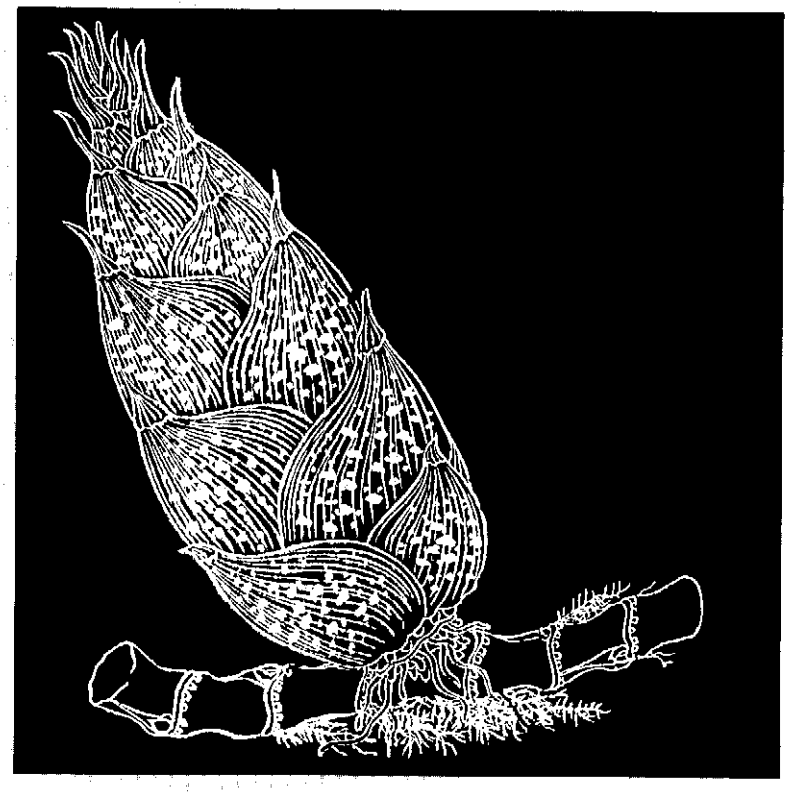
30. Square plan; tall pyramidal thatched roof; thatch of broad leaves. (Zaïre.)

31. Cave houses; caves often artificially enlarged; sometimes small courtyard in front surrounded by mud wall or fence; wattle and daub wall sometimes built across mouth of cave. (Tanzania, Kenya, Zaïre, Cameroon, Sudan, Chad.)

32. Underground or semi-underground "dug-in" buildings; rectangular in plan; sometimes with excavated passageway in front; walls of stone in mud mortar, wattle and mud, mud bricks or turfs; flat or slightly wagon-shaped roof of earth, mud and poles supported on many rows of forked uprights. (Tanzania, Ethiopia, Upper Volta.)

CHAPTER 5.

1. Rudofsky 1964.
2. Rudofsky 1964; condensed from the preface.
3. Denyer 1978: 4.
4. Fathy 1973: 19–21.
5. Ibid.: 22–4.
6. Ibid.: 24–5.
7. Ibid.: 25–6.
8. Ibid.: 26–7.
9. Ibid.: 31–3.
10. Ibid.: 33–4.
11. McClure 1950b.
12. McClure 1966:147–201.
13. Hidalgo 1980:1.
14. McClure 1950b.
15. Castro 1966, *passim.*
16. Ibid. The Castro material consists of strings of captions and brief introductions to a book of guadua photographs from western Colombia.
17. Hidalgo 1980:3–5. The movie from which the Hidalgo material in this chapter derives is available from CIBAM in Spanish or English. Address, see p. 305.
18. For an extended treatment, see *Extinction,* by Paul and Anne Ehrlich (1981), Random House.
19. Giono, Jean: *The Man Who Planted Trees and Grew Happiness;* reprinted in Brand 1980:79–80.



6. THE PLANT — BAMBOO BEHAVIORS

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"Plants are people, just like us.
You see them, they see you.
The earth isn't blind
and the mountains aren't foolish."

—Jose Valdez,
Mexican farmhand

TROPICAL AND TEMPERATE SPECIES

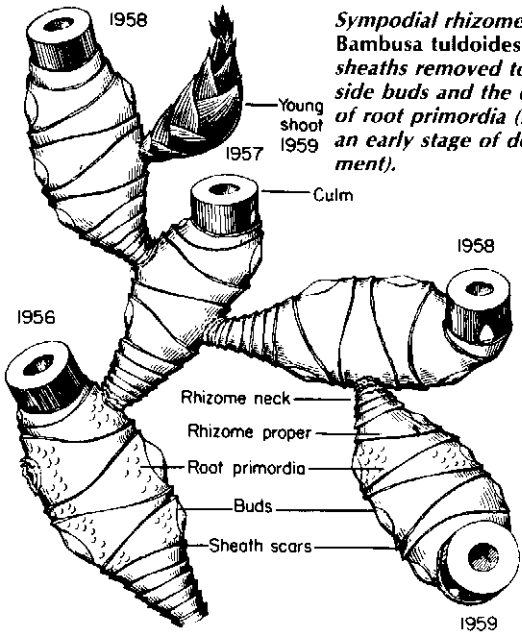
Grasses have proved the most useful plants on the earth for people, providing us with such common crops as wheat, corn, rice, barley, sorghum, oats, sugar cane—and bamboo. Bamboos are perhaps the most primitive subfamily of grasses, which includes some 76 genera embracing some 1200 to 1500 species. These are broadly divided into "sympodial" and "monopodial" species, according to their rhizomes, a rootlike system of growth underground.

Sympodial (clumping) bamboos.
Sympodial bamboos are clumping, frost-sensitive tropical species, some enduring temperatures slightly below freezing. In sympodial bamboos "shooting"—the growth of culms—occurs typically from summer to autumn or at the onset of the rainy season. It is apparently controlled by moisture levels; and in warm regions with frequent rainfall throughout the year, the growth of sympodial bamboos may be virtually continuous. The rhizome is thick and short, with asymmetrical internodes more broad than long. Side buds give rise to further rhizomes, with culms growing from the ends in tight or fairly open clumps, depending on the length of the rhizome neck. The midculm branches, swollen at the base, resemble the rhizome form; often they are bearded with root primordia (in rudimentary stage of development) on the dominant branch. Cross veining in leaves—called "tessellation"—is usually difficult to see.

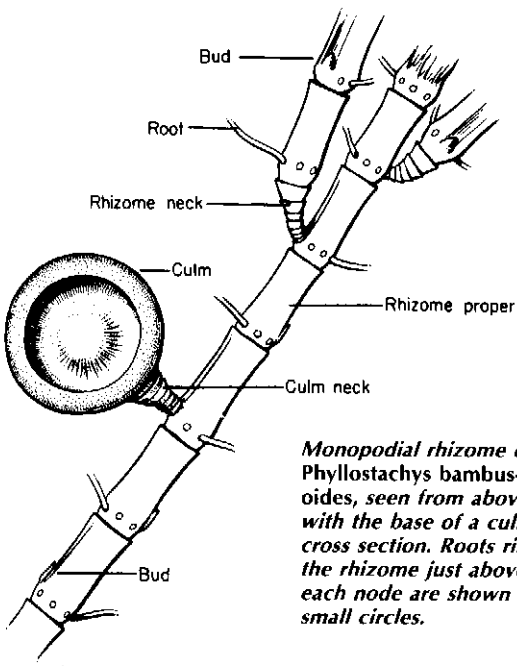
Monopodial (running) bamboos.
Monopodial, free-standing bamboos are hardy to a few degrees below 0° F and thrive in climates with pronounced but not severe winters, enduring even annual seasons of snow. The onset of shooting, typically in spring, is apparently controlled by temperature. The lengthy rhizomes are segmented like the culms above them, with symmetrical internodes more long than broad. The culms, growing from side buds at alternate nodes of the rhizomes, bear branches without root primordia, unswollen at the base. Tesselation is usually clearly visible in the leaves.[1]

RHIZOMES

The rambling rhizomes of monopodial bamboos may nudge their way through up to 20 feet of soil

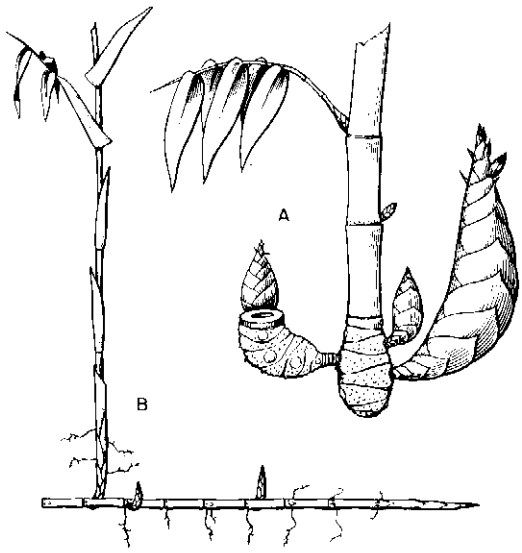


Sympodial rhizome of **Bambusa tuldoides** *with sheaths removed to show side buds and the dimples of root primordia (i.e., in an early stage of development).*



Monopodial rhizome of **Phyllostachys bambusoides,** *seen from above, with the base of a culm in cross section. Roots ringing the rhizome just above each node are shown as small circles.*

in their single spurt of growth. There is no increase in size after this, although the rhizome remains fertile for up to ten years, producing culms and other rhizomes that tangle underground in such profusion they hold firm in earthquakes and effectively diminish erosion on the steep slopes where bamboos, preferring a well-drained soil, grow well. The excavation of a quarter acre in Kyoto revealed rhizomes totaling weights up to 19,000 pounds in large species and lengths up to 53,000 yards in small bamboos.[2] That's roughly 40 tons per acre in large species, and 120 miles per acre in dwarf bamboos. Some 80 percent of this growth occurs in the top foot of soil, which accounts for bamboo's traditional reputation as guardian of the earth's fertility, stitching her hills together like an anxious grandmother.



(A) Sympodial rhizome of **Bambusa beecheyana.**
(B) Monopodial rhizome of **Arundinaria amabilis.**

A healthy and vigorous young rhizome is a yellow-ivory color. Its nodes are key points of growth, giving rise to a ring of roots to gather nutrients and buds to extend the community of culms above ground and rhizomes below. The nodes store nutrients as well for distribution to the most active centers of new growth in the grove. Like the culm nodes above, each rhizome node is snugly wrapped in a protective sheath. The rhizome tip is pointed and tough. If a monopodial rhizome encounters an obstacle too unyielding to pierce or too large to pass around, it will sometimes rise briefly above ground and dive below again until it ends its season of growth—and in some species, it bends up to form a terminal culm, exuding moisture before it to soften the soil. In a shooting grove where the ground is dry enough, a small circle of moisture indicates the spot where a new culm is about to break through the soil, its tender and rapidly multiplying tissue heavily wrapped in tough overlapping sheaths that effectively protect extending stem and branch buds tucked on alternate sides of each node.

GROVE FORM

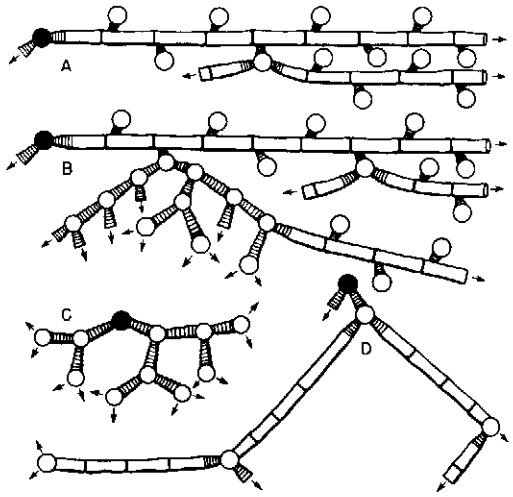
Surface growth reflects rhizome habit underground.

The form a stand of bamboo assumes above ground depends on the nature of the rhizome below. The open grove of free-standing culms is characteristic

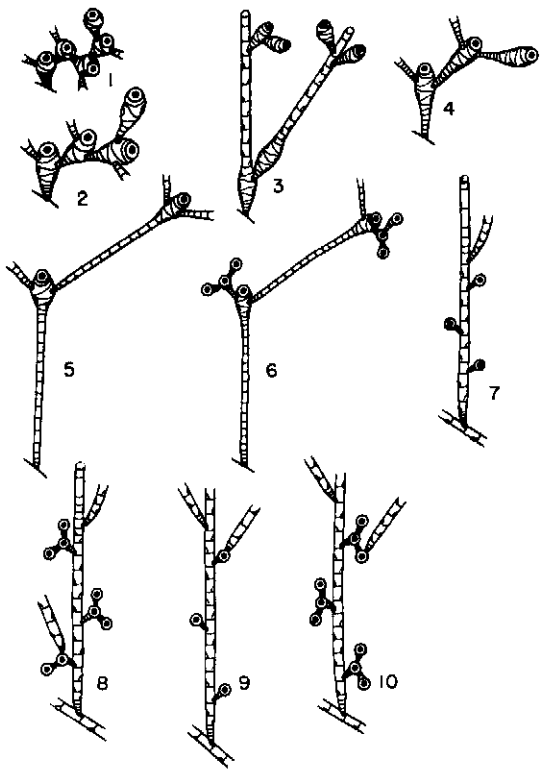
A botany experiment

Plant a hardy bamboo rhizome in 6 to 8 inches of soil in the bottom of a deep and narrow glass tank. A pipe to water the soil directly is placed in one corner, then the tank is filled with sand. Watering through the pipe keeps the soil moist and the sand dry. As the rhizome bud eventually swells and grows, the sand before it becomes damp.[3]

of most hardy bamboos native to temperate zones. The tight-clumping habit of more southern species supposedly evolved from this earlier rhizome form as an adaptation to harsh tropical sunlight and seasons of prolonged drought followed by torrential rains. A more crowded grove provided denser shade and a thicker blanket of moisture-preserving mulch from leaf fall as well as less rhizome surface to dehydrate in those long dusty months typical of many climates at the fat middle of the globe. The tendency to spread out or stay put is particularly critical when considering bamboo plantings in limited land. It should be noted that there are hardy "running" species whose rhizome growth is so lazy that they, in fact, form fairly compact clumps extending in a leisured creep: *Pseudosasa japonica* or



Rhizome types determine the clumping or running habit of a grove. (A) Monopodial rhizome with single culms somewhat openly spaced. (B) Monopodial rhizome with tillering culms produces scattered clumps above ground interspersed with solitary culms. (C) Sympodial rhizomes with short necks produce congested groves. (D) Sympodial rhizomes with long necks produce open groves, with culms up to six meters apart in some species. Temperate monopodials tend to scatter; tropical sympodial bamboos, to clump. The numerous exceptions to this rule are determined by the rhizome system of each species.



Rhizome systems of various species, seen from above. Open ends indicate further horizontal growth; a single circle (3, 7) signifies an occasional terminal culm at the end of a rhizome; a double circle, the cross section of a culm base. (1) Bambusa pachinensis: *a short-necked sympodial rhizome. (2)* Bambusa tuldoides: *a sympodial bamboo with rhizome neck shorter than the rhizome itself, which grows horizontally and then curves up into an erect culm. Produces compact tufts of culms generally characteristic of tropical species. (3)* Arundinaria pusilla: *distinguished by the tendency of the rhizome to form terminal culms. (4)* Sinarundinaria nitida: *an elongated rhizome neck that gives some sympodials an open grove form.* Bambusa vulgaris *is a common example. (5)* Melocanna baccifera: *long-necked sympodial rhizomes a meter or more long create open groves of widely spaced culms. (6)* Yushania niitakayamensis: *long-necked sympodial rhizomes with tillering culms produce scattered clumps united underground. (7)* Shibataea kumasasa: *monopodial rhizome with terminal culm and solitary culms from side buds, which tend to tiller in old age. (8)* Arundinaria tecta: *monopodial rhizome with terminal culms as well as culms from side buds. These culms, from their own underground basal buds, give rise to other rhizomes and tillering culms. (9)* Phyllostachys bambusoides: *the most broadly typical form of the monopodial rhizome. Side buds produce new rhizomes or solitary culms that do not tiller except when damaged or grown under unfavorable conditions. Terminal culms on rhizomes occur only rarely, as when rhizomes emerge on a steep hillside or encounter an obstacle such as a large rock that drives them above ground. (10)* Chusquea fendleri: *a South American bamboo bridging both rhizome forms. Swollen sympodial rhizomes occur in tillering clumps from side buds of a long rhizome monopodial in form.*

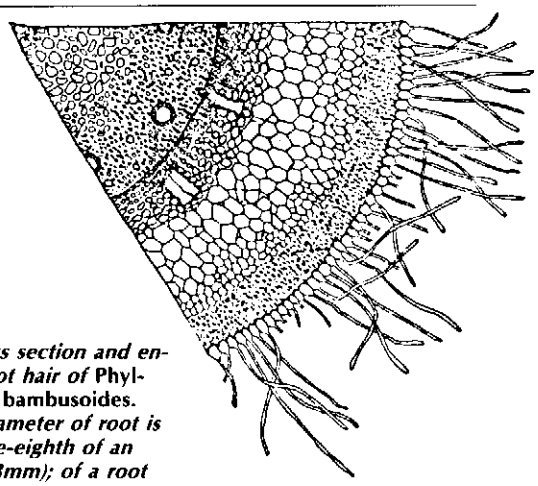
Phyllostachys aurea are common examples. By contrast, judging only by the grove formation above ground, one would regard some "clumping" bamboos as running, temperate species, owing to the uncommon length of their rhizome neck—up to 6 meters in the extreme case of the giraffe of bamboo tropical rhizomes, a *Guadua* species from Peru.[4]

For concerned gardeners, the style and rate of spread are considered under the descriptions of individual species below.

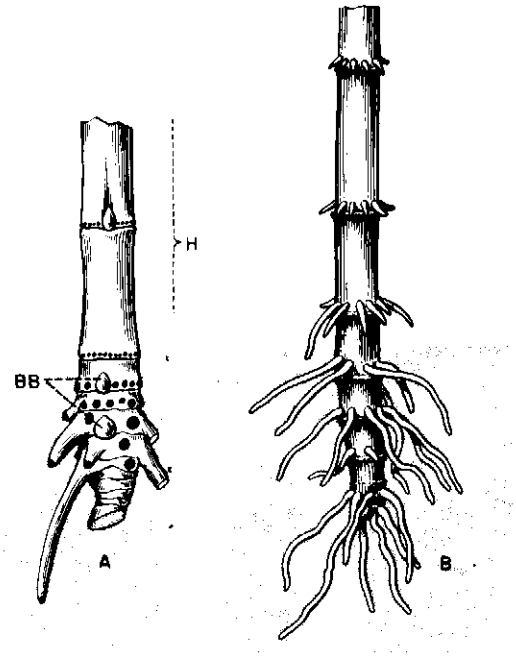
ROOTS

Survival value of roots in the air.

Bamboo roots are the only portion of the plant not growing in segments of nodes and internodes. They are fibrous, roughly cylindrical, thin, and do not increase in diameter with age. The largest roots of the largest species may be up to a centimeter thick and a meter long. In bamboos, as in other grasses, roots are primarily "adventitious," that is, not occurring at the usual location. Instead of growing from the primordial root, they extend from nodes of rhizomes and basal underground nodes of culms. In a number of sympodial bamboos, root primordia —in an early, dormant state—ring the swollen base of dominant branches at midculm nodes. Many species, principally sympodial bamboos, also bear root primordia at nodes as high as midculm, always diminishing in size at successive nodes in the direction of the tip. *Bambusa vulgaris, Dendrocalamus asper, Gigantochloa verticillata, Chusquea pittieri* are sample species with aerial roots. The genus *Chimonobambusa* is distinguished among monopodial bamboos with several species —for example, *Ch. quadrangularis*—bearing dry, brittle rootlettes up to midculm or higher. Aerial roots presumably anticipate the possibility of the culm being prematurely felled by storms or other falling plants. The roots are there, ready to help establish new culms and rhizomes at a number of nodes.



Root cross section and enlarged root hair of* Phyllostachys bambusoides.** ***Actual diameter of root is about one-eighth of an inch (3.63mm); of a root hair, .0004" (0.01mm).



(A)* Phyllostachys nigra.** ***Sheaths removed from culm base to show developing young roots;* BB,** ***basal buds. (B)* Chimonobambusa quadrangularis** ***(square stem bamboo) is ringed above culm nodes by spiney aerial roots (adventitious roots) diminishing in length at each higher node and finally disappearing.

Whatever their survival value, the visual effect of culms is always enhanced by nodes or branch bases trailing roots. They provide an interesting contrast—in color, texture, and shape—to the polished and erect stance of culms. In some species, such as *Dendrocalamus asper,* they are long enough to suggest a bearded and venerable ancient. As short spikes ringing the culm in the square stemmed *Chimonobambusa quadrangularis* they provide a formal frieze bristling with vigor, an orderly crownlike adornment for a species already distinguished by its angled canes.

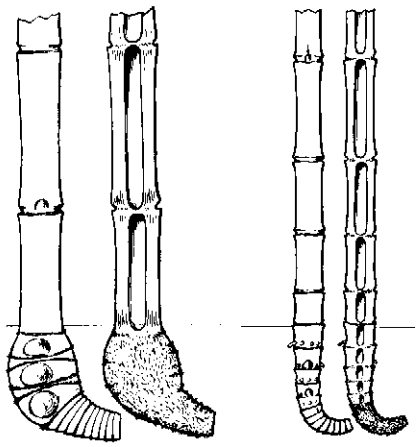
CULM

Visible stems: fingers of a hidden hand.

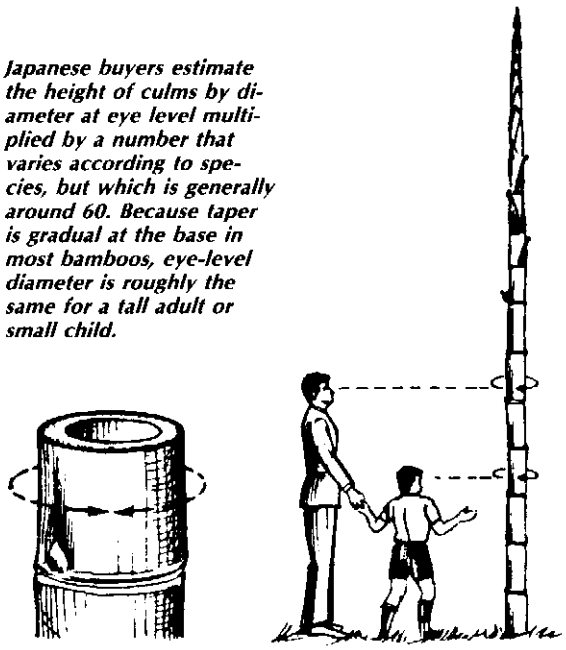
The growth of the bamboo culm, the most spectacular of the plant's visible behaviors, varies greatly depending on species, soil, age of stand, and climate. Larger species may average between 3 to 16 inches in a day, with a recorded growth for *Phyllostachys edulis* in Japan of 47.6 inches in one 24-hour period.[5] Night growth may be two to three

times the growth by day in some species; in others, the reverse is true. Sympodial bamboos complete their growth in 80 to 120 days. Monopodial species reach 93 percent of their total height within one month, then taper off with a second, slower period of roughly equal duration. After this the culm hardens and matures, drops branches that may sag eventually with a bushy abundance of foliage but does not increase in height or diameter: The size reached by the eighth or ninth node to emerge from the soil in a shooting culm will be roughly the girth of the developed stem. "Like most of the plants in the great subclass of the vegetable kingdom called the monocotyledons, there is no provision for growth in thickness once maturity has been attained."[6] This abrupt growth and abrupt halt is less surprising when we remember that a culm is not a plant, but a piece of plant.

Bamboo family.
Most people, until told otherwise, unconsciously regard individual bamboo culms as trees, each a separate, living whole. In fact, of course, the stems are airy branches of a single life whose structural foundation is underground, invisible. Apparent individuals are members of a system of intersurvival, a tuft of giant grass: sharing, cooperative, striving for the common good of the grove, gathering food and drink in root and leaf, storing it in rhizomes, to be sent then to the "bamboo kids," *takenoko,* as the new shoots are affectionately known in Japanese. From each according to its vitality, to each according to its need. In many cultures, this collective



Lower culm of* Dendrocalamus latiflorus *(left) and* Arundinaria fastuosa *(right).



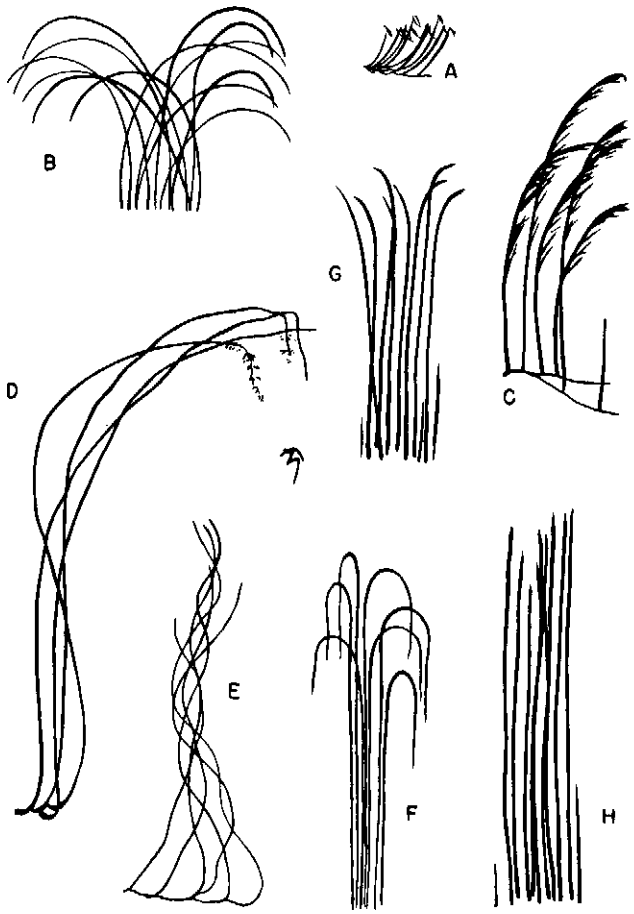
Japanese buyers estimate the height of culms by diameter at eye level multiplied by a number that varies according to species, but which is generally around 60. Because taper is gradual at the base in most bamboos, eye-level diameter is roughly the same for a tall adult or small child.

pattern of bamboo's growth was taken as a rebuke to egotism and an image of familial unity.

Grove maturity affects culm size.
Culm growth depends not only on species and climate and soil, but also on the maturity of the grove. When a new grove is established, from planting of rhizome or seed, the gradually extending system of rhizomes becomes more rich in the food necessary to produce culms. Thicker and taller stems are produced each year in greater numbers until the maximum stature and productivity for the species is reached under specific local conditions of weather and soil fertility. The grove will then continue to produce plants of maximal size until it flowers.

Longevity.
Culms may be short-lived in some species or cut back by harsh winters in the case of ornamentals introduced in climates colder than their native homes. A life of five to ten years is not uncommon, and some species—*Phyllostachys bambusoides,* the Japanese "timber bamboo," for example—produce culms living as long as twenty years. Size is as variable as duration: from pygmy *Sasas* in northern Japan 6 to 10 inches tall to *Dendrocalamus* species up to 120 feet and a reported 90 meters in a giant culm of *Dinochloa andamanica.*[7]

A highly simplified sketch of bamboo heights would reveal maximal growth in equatorial regions, diminishing towards the poles—not surprising since every 10° C fall in temperature supposedly reduces



Culm stance: diagrammatic examples of some typical postures of a grove. (A) **Sasa palmata.** ***(B)*** **Sinocalamus beecheyanus.** ***(C)*** **Phyllostachys nigra.** ***(D)*** **Schizostachyum hainanense;** ***(E)*** **Dinochloa scandens.** ***(F)*** **Sinocalamus affinis.** ***(G)*** **Bambusa textilis.** ***(H)*** **Arundinaria amabilis.**

chemical processes in plants by 50 percent.[8] In form, the culms of some species are ramrod erect but more often nodding much or slightly at the tip. Other bamboos are "clambering," specially equipped to climb other plants.

Culm stance.

Culm stance also helps distinguish genera. Erect in *Pseudosasa japonica,* arching in most *Bambusa* species, plumelike in most *Phyllostachys,* in *Schizostachyum hainanense* it is clambering. In *Dinochloa* species the individual culms are more aggressive in their attitudes and gyrate like morning glories, like vines that, finding no external means of support, twine around each other. This is commonly seen in *Dinochloa,* where the twisted whirlwind of a large, unsupported clump of this bamboo suggested the genus name that means "eddy grass" or "whirling grass." Other forms include the whiplike *Dendrocalamus flagellifer,* stiff and erect for two-thirds its length, ending in a long, drooping tip. Many *Bambusa, Schizostachyum,* and *Gigantochloa* have upright culms with arched tips. Perhaps most commonly, the culm stance is strictly erect as in *Bambusa tuldoides* and all *Arundinarias.*[9]

Branching.

Culms of very young plants of most species are typically branching or bud-bearing at all nodes. Mature culms of developed groves are sometimes branched throughout, but more often they are branchless and even budless at lower or even midculm nodes. In some species, such as *Bambusa textilis,* nodes may lack branches up to three-quarters of the culm, which increases both their usefulness and the difficulties of propagation. Sometimes —as in *Chimonobambusa quadrangularis*—lower to midculm nodes may be ringed by short, thornlike roots. In some species the difficulties of harvesting bamboo are greatly increased by wicked thorns—hard and sharp dwarfed twigs—at the culm base and higher. Various species of *Guadua*—a much used Central and South American bamboo—have thorns that can shred denim to rags in a day's harvest; cut branches left on the ground can readily puncture a stout boot. *Bambusa arundinacea*—"giant thorny bamboo"—is another species as armed and dangerous as it is desirable: In spite of its bristly defenses, it supplies nearly half the raw material for India's bamboo paper pulp production, which is the largest in the world.

Internodes.

Internodes generally increase in length to midculm, then decrease to tip. Much more rarely, internodes sometimes also increase in diameter as well from base to midculm. An interesting feature of culm anatomy in bamboos is that their constituent fibers reflect the grosser form: Their length and thickness correspond to the internode length and culm diameter. They increase in length from base to midculm and then shorten, like the internodes, to the tip. Their width, like the diameter, decreases continuously with culm height. Both length and width are greatest in the inner portions of the wall.

Fiber grass. Composite materials reflect bamboo anatomy.

From a builder's viewpoint, the architecture of the bamboo culm presents an optimum configuration: fibers of greatest strength occur in increasing concentration toward the periphery of the plant. The center is hollow. These long, slender, elastic fibers

are ideally suited for the skeletal framework of the plant because bamboos are shallow rooted and extremely tall. With 80 percent of the rhizome in the top foot of soil, and the rest rarely extending below a yard, the larger species are anchored in earth with foundations roughly 2 to 3 percent of their height. Only extreme resilience in the culms could keep them from being easy victims of the wind. In fact, the reverse is true: Bamboos became a proverbial symbol for resilience in adversity as oriental peoples noticed, they only bent in storms that broke the oaks, then stood up again, green and living, when the wind died.

"The essential basis for the remarkable properties of bamboo has only been revealed by recent work on two-phase materials such as fiberglass. Composite materials combine substances of high and low tensile strength and modulus of elasticity so that they can absorb loading stresses, which would rupture the weaker component, and at the same time isolate imperfections in the individual units of the stronger component. Bamboo does just this; in bamboo strong high-modulus fibers of cellulose are combined with a low-modulus plastic matrix, lignin. Hence its multifarious uses in Chinese culture, where also the two-phase structure was dissociated by retting to give the high-tensile-strength fibers alone. We shall find later on a parallel to this combination in the pattern-welding of sabers, where wrought iron and steel were forged together. Nowadays we have high-tensile-strength glass fibers embedded in a matrix of plastic resin, as described by Slayter, with a clear realization of the historical background of these triumphs of modern technology."[10]

Strength of steel.
The bamboo culm combines a certain gentle capacity to yield with a strength that rivals steel.

> The Puerto Rico Experiment Station made strength tests of *Bambusa tulda,* a good bamboo but probably not our strongest; 52,000 pounds per square inch were required to break it. Walnut, according to these tests, required 20,000 to 22,000 pounds per square inch, while the steel commonly used for reinforcing concrete required about 60,000 pounds. Certainly such an easily grown plant as bamboo with culms of this strength can have wide usage . . . In hurricane countries their great strength makes them the best possible planting material for windbreaks . . . In the First World War, when steel was difficult to obtain in China, bamboo was used in building construction to reinforce concrete.[11]

Tough skin.
The durability of bamboo culms in the grove is partly owing to their bones, their fiber; but their longevity also derives in part from the unusual toughness of their skin. If you walk in a grove of giant bamboos not cleared by a regular harvest, you find the new culms of most species a dazzling green, hard as your fingernails. Their smooth emerald surface looks made that morning by a god from Oz, but the crusty grandfathers of the grove—who have survived long enough to gradually break down the vigorous resistance of living culms to insects and fungi—are an amazing palette of grey-white silvers and russets and golds. Dozen-colored lichens and mosses embroider them like old fence posts. William Porterfield, a Western botanist resident as a teacher for many years in Shanghai in the 1920s and 1930s, describes in detail the gradual process resulting in the noble ruin of a grove, witnessed in full glory only where bamboo enjoys prolonged neglect.

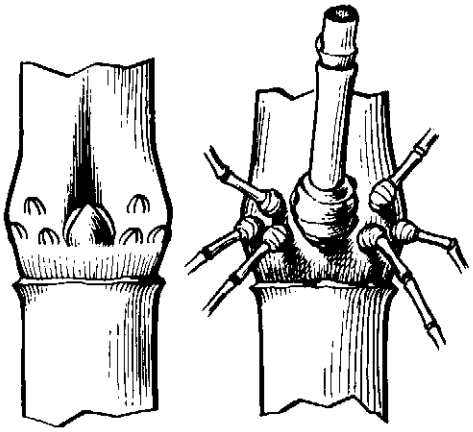
> The smooth polished exterior of bamboo poles is a remarkable, almost unnatural characteristic. No finish applied by human hands is so smooth and hard. The immediate cause is the secretion by the epidermis of wax and silicon. The waxy coating is the basis of the polish, while the silicon compound is responsible for most of the hardness. Some idea of the quantity of silica contained in bamboos may be gathered from the fact recorded of one species, *Bambusa tabacaria,* that it will emit sparks when struck with an axe . . . Even parasites find it difficult to effect an entrance so long as the epidermis is left intact. In time, however, the combined action of moisture, weak mineral acids, mildews, and microorganisms succeed in forcing an opening in the protective armor of the culm . . . The scar or ring just below the raised ridge of the joint proper is a favorable place of attack from fungi and bacteria. As a tender shoot the joint is enclosed in a protective sheath-leaf. Later, as each section in order attains its full size, the sheath-leaves fall off, leaving behind a scar which, like the leaf-scars on trees, becomes thoroughly corked over as a protection against the loss of internal moisture and the invasion of pests. But this does not always take place without defect, nor can the chance always be avoided of attacks by boring insects in the wake of which spores and penetrating mycelia find their way into the tissues and eventually the joint. The toughness of the skin, however, is attested by the fact that in the bamboo forests pieces of cane are found with the wood entirely rotted out, leaving only the epidermis as a shell.[12]

BRANCH COMPLEMENT

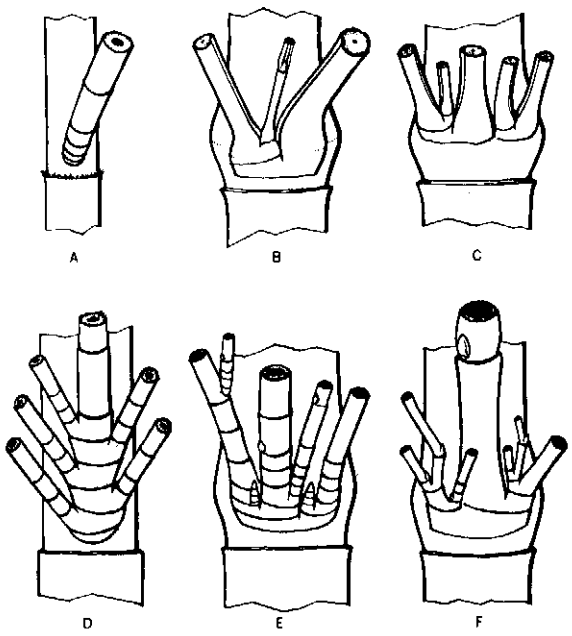
Uses for identification.

Branches emerge from culms on alternate sides, just above nodes, from single buds just below the middle of the sheath that covers them. In all bamboo genera—with a single exception—the frequent abundance of branches ramifies from a single bud at the base of each branch complement. Only the South American genus *Chusquea* bears a principal bud flanked by two to many smaller ones that in some species (for example, *Ch. pittieri*) completely ring the culm. Some buds break in ascending order on the culm as successive internodes complete their growth. All *Phyllostachys* species and the only bamboo native to the continental United States—*Arundinaria gigantea* and *A. tecta*—follow this pattern. *Semiarundinaria viridis* breaks branch buds at midculm, and the process extends to higher and lower nodes simultaneously. Others break buds from the top down, with a period of dormancy lasting up to several weeks in the case of such species as *Bambusa textilis.*

Most young immature bamboos bear branch buds at all nodes. In more mature plants, basal buds may remain dormant indefinitely or even be lacking entirely up to ½, ⅔, or even ¾ the height of the culm. *Bambusa textilis* and *Arundinaria amabilis* are extreme examples of this condition, which enormously facilitates harvest and use—and consequently increases the value of the species. Anyone who has ever removed branches for basketry or other crafts will appreciate the advantage of a species virtually without them in that portion of the culm with thickest walls and widest diameter.



Branch buds (left) and complement (right) of the genus* Chusquea.** ***Multiple buds depart from the norm of all other bamboos, in which branch complements of up to 35 branches spring from the base of the dominant branch(es) emerging from a single bud.



***Proliferation of branches from the base of midculm branch complements in six species. (A)* Sasa palmata.** ***(B)* Phyllostachys dulcis.** ***(C)* Shibataea kumasasa.** ***(D)* Arundinaria tecta *var.* decidua.** ***(E)* Arundinaria simonii.** ***(F)* Arundinaria fastuosa.**

Midculm branch complements are usually most typical of a given species. Lower branches are usually less completely developed, and branches at the upper nodes are frequently less distinctive of the genus and species.

Number per node.

The ramification in some genera is characteristically minimal. Species of the genus *Sasa* are distinguished always by a single branch at each node without basal buds on it to produce others. *Phyllostachys* species typically bear two unequal branches above a prominent "supranodal ridge" with, occasionally, a skinny and diminutive third emerging from a basal bud on the smaller of the original pair. The bud of some bamboos—such as *Melocanna baccifera* or the known species of *Schizostachyum*—may branch before even bursting through the prophyllum (the sheath at the first node of a branch) as a tuft of slender, subequal branches, with the primary branch not noticeably greater in size.

In other genera, such as *Bambusa, Dendrocalamus,* or *Gigantochloa,* the primary branch remains strongly dominant, and the branchlets emerging from its basal nodes are progressively thinner and shorter. In species of these genera, the dominant branch tends to resemble the culm itself

Identification.

Branches per node in various genera provide one gross preliminary form of identification. One branch per node tells you the bamboo is *Sasa, Sasaella,* or *Pseudosasa.* One branch at lower and upper nodes and three at middle nodes indicate *Pleioblastus, Semiarundinaria,* or *Sinobambusa.* One strong branch, surrounded by a dense cluster of short, slender, subequal ones is unique to *Dinochloa.* Two branches, unequal, with often a very small third between them are the infallible sign of *Phyllostachys.*[13]

in miniature, with the swollen base of the branch appearing like a reduced rhizome. The basal internodes of the branch are solid and the proximal nodes—those nearest the culm—are generously ringed with root primordia. *Bambusa tulda, Bambusa textilis, Bambusa vulgaris, Gigantochloa apus,* and *Dendrocalamus asper* are some common examples.

Dwarf branches—thorns.

In some genera with scandent culms—*Chusquea* and *Dinochloa*—principal branches may be nearly as thick and long as the culm itself, an obviously useful feature for vinelike climbers. In self-supporting culms, there is often a correspondence between the lengths of culm internodes and the lengths of primary branches growing from their nodes. Some genera of bamboos—*Guadua* and *Bambusa*—produce dwarfed, sharply pointed branches, or thorns, usually more densely at lower portions of the culm.[14]

SHEATHS

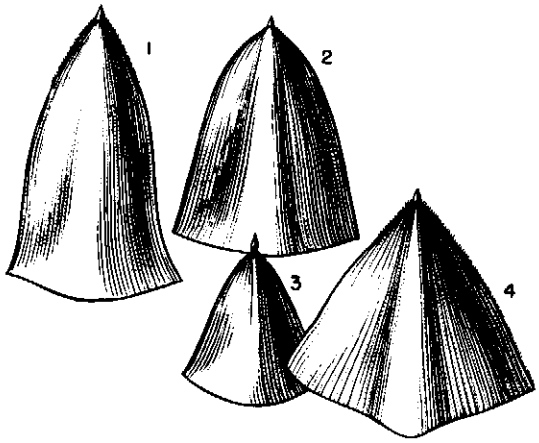
Protective packaging on rhizome, culm, and branch.

Every node of rhizome, culm, or branch bears a sheath that protects it during growth. The rhizome sheaths are sharply pointed shields enveloping the meristematic tissue shoving through the soil, smooth and shiny on the inner surface—like culm and branch sheaths—permitting the growing rhizome to slide forward with minimum friction, like a piston in its cylinder. Of all sheathing organs, rhizome sheaths vary least in form from node to node. The blade—at the tip of the sheath proper—is negligible in size, and there are no auricles, which in culm sheaths provide an important hint for distinguishing between species.

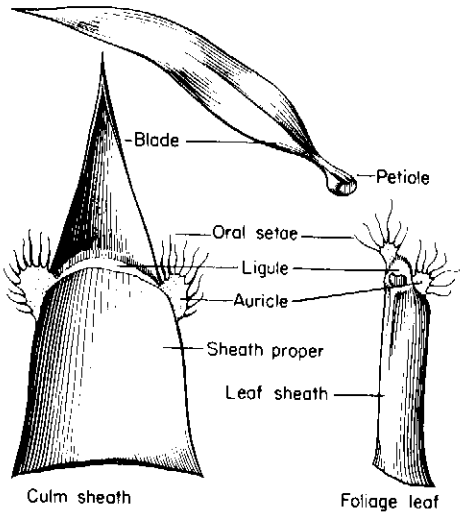
Culm sheath for species identification.

The culm sheath is a more complex structure and, like the branch complement, is most characteristic of each species at midculm nodes. It is a primary means of distinguishing closely related species in a genus, depending on its size, color, shape, and the form of the blade, auricles, ligule, and oral setae at its tip. These appendages may be lacking, reduced, or much altered at base and tip of the culms. Basal sheaths approach the form of rhizome sheaths; at culm tip, they take the form of a leaf sheath with a stalked blade. Midculm sheaths are consequently those examined for species identification.

The culm sheaths serve to distinguish bamboos by their behavior as well as their form. *Sasa* sheaths



***Rhizome sheaths. The extreme reduction of the sheath blade is typical of all species. (1)* Semiarundinaria viridis. *(2)* Sasa kurilensis. *(3)* Arundinaria variegata. *(4)* Phyllostachys bambusoides.**



Culm sheath and foliage leaf sheath of* Bambusa *genus, not drawn to uniform scale. In species without auricles, oral setae are sometimes called shoulder bristles. Clues to species identification include the shape, size, color, and hairiness of culm sheaths; their duration on the culm; and the forms of auricles, oral setae, and blades of both clum and leaf sheaths.

Bamboo leaf.

are persistent, *Phyllostachys* deciduous, that is, tending to fall off quickly. *Arundinarias* vary from species to species. Some bamboos—for example, *Guadua angustifolia*—have sheaths that fall readily from upper nodes while remaining for years below. In some species of *Chusquea* one edge of the sheath is fused to the sheath surface some distance up the internode in such a way that the branches burst through the sheath tissue, rupturing it in a characteristic way. Some species all but lose the sheath, which hangs by a small portion at the center of the base, fluttering in a certain manner that serves as a clue to its identity (for example, *Arundinaria fastuosa*).

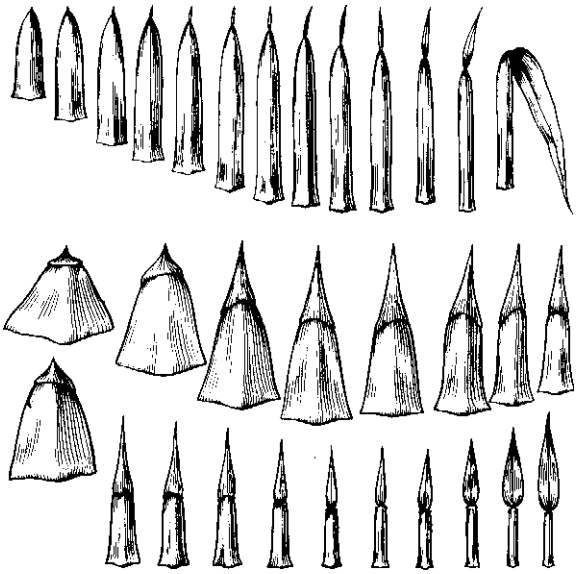
Branch sheaths repeat culm sheaths in a miniature form, which becomes smaller and more generalized in successive orders of branches. They may be persistent or deciduous. In clambering species whose dominant midculm branches approach the culm size in diameter and length, the culm and branch sheaths are virtually identical *(Chusquea simpliciflora, Melocalamus compactiflorus).*

Leaf sheaths cover the tips of all culms and branches. Their blades, the familiar leaves or foliage of bamboos, are "the plant's principal source of elaborated food."[15] The leaf sheath is distinguished from other sheathing organs by a blade much larger than the sheath proper, and by the *petiole* or stalk that connects the leaf base to the sheath tip. Leaf sheaths are much longer than their respective internodes and consequently overlap, each nearly covering completely the sheath above.

LEAVES

Abundance, tessellation.

Bamboo's vitality is in part owing to its leaves, which are usually plentiful and range from tiny to immense. Hair fine, scarcely 3 mm wide on *Arthrostylidium capillifolium,* leaves are 5 meters long by ½ meter wide in *Neurolepis elata* from the Andes.[16] The annual leaf fall of bamboos is commonly 4 inches deep, and in many species roughly equals in weight the year's growth of new culms. Each leaf is tightly rolled up during development, with one edge, not the tip, at the center of the roll. The parallel secondary and tertiary veins of all leaf blades are tessellated—connected by transverse veinlets, which are weakly to strongly visible on one or both surfaces in hardy, monopodial species and obscured to superficial view in sympodial bamboos by overlying tissue. Foliage is commonly



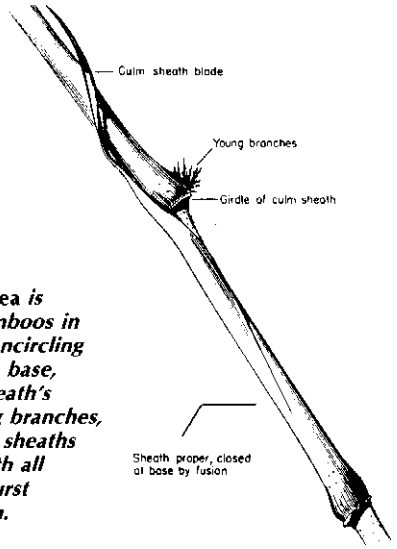
Culm sheaths of successive nodes from a single culm of* Pseudosasa japonica *(above) and* Bambusa pachinensis *(below). Midculm sheaths are used for purposes of identification.

Basal sheaths resemble the rhizome sheaths, while at the uppermost nodes the culm sheath, with much more prominent blade, resembles the leaf sheath and blade.

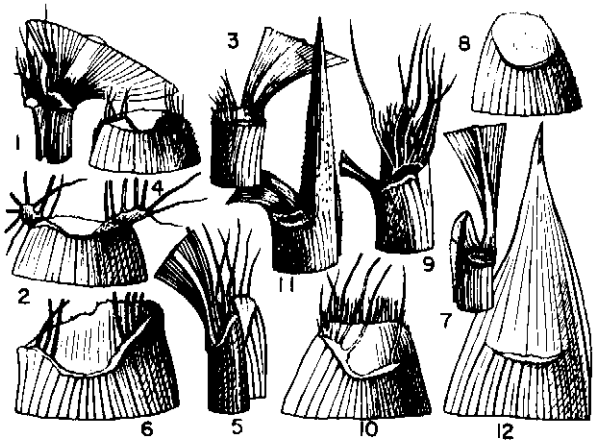
renewed annually from leafy twigs but is diminished or stopped when flowering starts. Extreme drought causes some species such as *Bambusa vulgaris* or *Dendrocalamus strictus* to shed leaves completely. Bamboo's autumn is generally in spring. The leaves from the last season fall gradually and are inconspicuously replaced by fresh fabricators of nutrients for the grove at the time when the plant needs all the energy it can get to send shoots speeding up.

Urban oxygen injection.

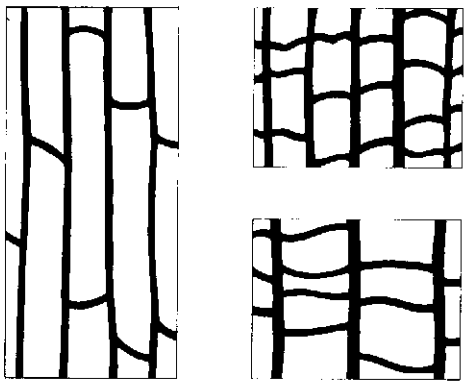
When in a grove, look carefully and you will find



The genus* Chusquea *is unique among bamboos in the fusion of the encircling culm sheath at the base, resulting in the sheath's persistence. Young branches, instead of shoving sheaths aside or off, as with all other bamboos, burst through the sheath.



Leaf sheaths of various bamboos, with inner and outer views of the tip showing various forms of auricles and ligule. (1, 2) **Bambusa shimadai.** *(3, 4)* **Sasa tsuboiana.** *(5, 6)* **Arundinaria variegata.** *(7, 8)* **Phyllostachys pubescens.** *(9, 10)* **Phyllostachys formosana.** *(11, 12)* **Shibataea kumasasa.** *All are drawn at the same scale.*



Tesselation, the mosaic pattern of longitudinal and transverse veinlets in a leaf, occurs in all bamboos but is a visible characteristic of hardy, monopodial species. It is hidden from the unaided eye by tissue in sympodial bamboos, whose leaves are often more tough and leathery than those of northern species.

that, in a cluster of leaves there will often be one which, even without the least breeze stirring, quivers with an astonishing rapidity, much faster than your eye can register. The effect of these scattered, extra-eager leaves is to give the whole culm a constant tremble of vitality, even in the stillest air. The evergreen foliage of bamboo is, of course, the chief reason for its popularity as an ornamental. Dense and rapid shade, a visual buffer that increases privacy and diminishes the effect of architectural errors, a muffler to mute the roar of traffic, an injection of oxygen into urban smog—the leaves of bamboo are one of its best pieces . . . and its biggest: One culm of Japanese moso—*Phyllostachys edulis*—had a total of 63.8 square meters of shimmery surface shared by 88,762 leaves.[17]

Appearance: A simple experiment.

We return often to the leaves of bamboo in the course of this book; we can leave them for the moment with some words of Alexander Lawson, whose experience in cultivating hardy ornamental bamboos derives from many years as head gardener at one of the largest European collections in Uplyme, East Devon, where over fifty species are established:

> The upper surfaces of the leaves are invariably smooth and glistening, and after a shower of rain they flash and flicker like mirrors when the sun catches them. The undersurfaces of the leaves are always somber in color and often coated with minute hairs. The dull matt effect is produced partly by innumerable minute peglike projections protruding from the lips of the many *stomata* and are designed to prevent globules of moisture from adhering and choking the entrances of the tiny breathing passages. Immerse a leaf in water and it will be seen that whilst the upper surface retains its smooth and glossy appearance, the underside acquires a glistening silvery coating, formed by the numerous bubbles of air trapped and held by the pegs. The leaf can be left immersed in water for a considerable period, and even agitated from time to time, but the pegs will continue to hold onto the air bubbles and will do so until the cell structure of the leaf begins to decompose. This simple experiment could provide an interesting discussion point for school plant biology classes.[18]

Leaf blade of **Phyllostachys pubescens,** *in cross section, before opening. Developing leaves of all known bamboos are rolled up tightly, with one edge at the center of the roll.*

FLOWERING

Cycles: Flocks of flowers.

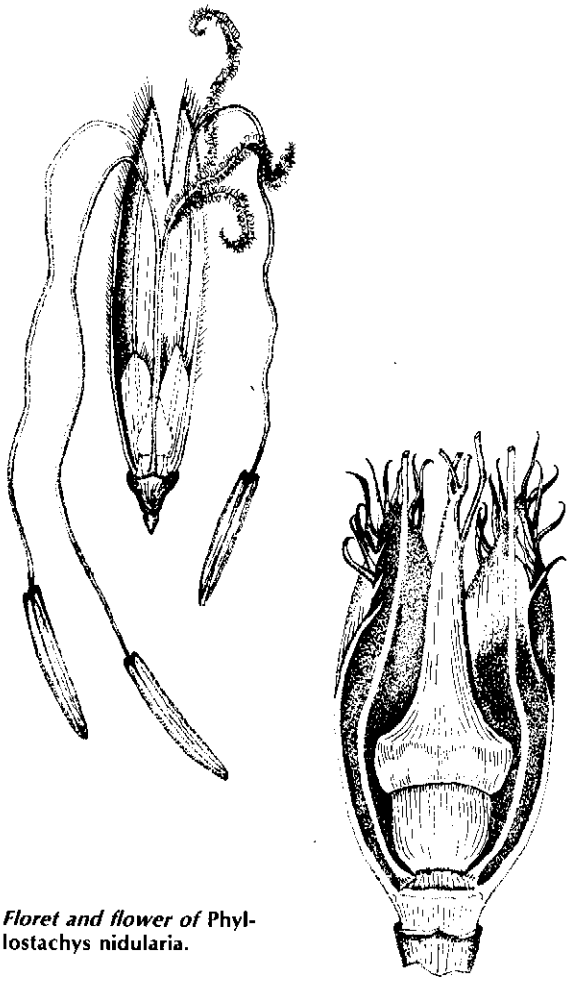
The flowering cycle of bamboos is one of their most unusual, disputed, and botanically mysterious characteristics. It varies from 1 to 120 years "according to numerous but weakly documented records" on

the widely varying habits of different species.[19] Some flower annually; others sporadically at frequent but irregular intervals; but the pattern most peculiar to bamboos is "gregarious": Crowds of plants within groves, in crowds of groves stretched across continents, if connected genetically—alerted by some unriddled mechanism in the cells, some clock or calendar that dates the age of the genetic stock—hundreds then thousands, then hundreds of thousands of plants suddenly stop making culms and rhizomes and start making tiny flowers, as inconspicuous, individually, as they are rare. Gregarious flowering may occur over small areas or cover hundreds of square miles. It has been seen beginning in one area and spreading in a specific direction, requiring a few years to cover the entire flowering zone, continuing sometimes as long as from five to fifteen years, with fruit production ranging from abundant to zero. Many species are partly or completely sterile. Common among bamboos, gregarious flowering is characteristic also of a palm, the Talipot *(Corypha)* of south India, but the occurrence is virtually unknown among other plants.[20] Many variables, considered as possible causes, have been dismissed:

> Studies in Japan have failed to show any relation between flowering time and age, size of clump, thickness of stem, soil fertility or moisture, exposure to sun, climatic factors or locality differences . . . In India . . . physiological disturbances caused by injury, cutting, or prolonged hot, dry weather have been mentioned as possible stimulants to flowering, but there seem to be numerous exceptions. Obviously more study is needed on this question.[21]

A blooming mystery.
Researching a phenomenon whose ample rhythm spans several lifetimes requires the patient—almost fanatically patient—collaboration of generations of students of bamboo behavior. "In a test of their blooming cycle, *moso-chiku (Phyllostachys mitis)* seeds were sown in 1912 by Tokyo University in its Chiba experimental grove and by Kyoto University in its Kamigamo experimental grounds. Neither have bloomed yet."[22]

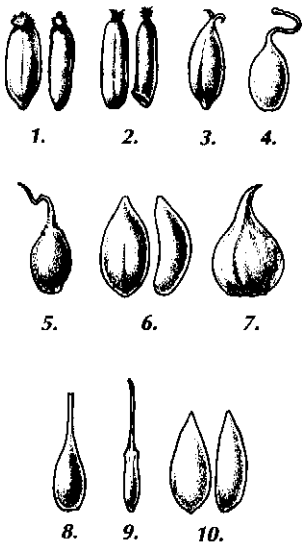
Death of groves.
The flowering of many species is followed by the death or severe setback of groves. The larger species are generally the most important economically, and these take the longest to reestablish themselves from seedlings. *Dendrocalamus strictus,* for example, may require twelve to thirteen years to reach



***Floret and flower of* Phyllostachys nidularia.**

mature statures again in a grove after flowering. Aided by conscious human care, this can be reduced to six years. If a given species is important in the local economy, the cycle becomes crucial, and in parts of India people's lives are even counted in *kutung* units of bamboo flowerings. In Japan, when the principal commercial species for baskets and construction, *madake (Phyllostachys bambusoides)* flowered in 1844–46, its excellent wood became so scarce that one culm was worth three bags of rice. In the case of species producing an abundance of seeds, flowering in India has sometimes helped relieve famines occasioned by prolonged drought, which some observers felt in fact triggered the flowering itself. (*Dendrocalamus strictus* and *Bambusa arundinacea* are the species involved.)

Famine relief and rodent explosion.
Although bamboo seed has often relieved human hunger, it has often been bad luck for farmers be-



Seeds of ten species. (1) **Bambusa glaucescens,** ***dorsal (back) and lateral (side) views, times 1½. (2)*** **Bambusa longispiculata,** ***dorsal and lateral views, times 1¼. (3)*** **Chimonobambusa marmorea,** ***dorsal view, times 2½. (4)*** **Dendrocalamus asper,** ***times 4. (5)*** **Dendrocalamus strictus,** ***times 2¼. (6)*** **Guadua aculeata,** ***dorsal and lateral views, times 3. (7)*** **Melocanna baccifera,** ***times ⅓. (8)*** **Ochlandra travancorica,** ***times 1. (9)*** **Phyllostachys pubescens,** ***ventral (front) view, times ¾. (10)*** **Pseudosasa japonica,** ***ventral and lateral views, times 2¼.***

cause of the swarms of rats attracted to the groves. In June 1855, a species of *Sasa* bloomed in a mountainous area of Japan in Yamagata Prefecture, and the hordes of wild rats that arrived to eat the seeds also feasted on a number of surrounding crops. About 350,000 rats were captured. In 1966, "all the sasa in a highland area of 10,000 hectares in central Ehime Prefecture on the island of Shikoku bloomed and bore seeds. An estimated 170,000 rats gnawed at the *hinoki* (Japanese cypress) growing there, causing it to wither and die."[23] In southern Brazil, following the heavy seeding of a species of *Merostachys,* similar invasions—*"ratadas"* as they are locally called—periodically occur.

Seed scarcity the norm.
Because of the spectacular nature of such reports, a general notion that bamboos seed heavily has become widespread. McClure, on the basis of over forty years of personal observation of flowering plants of twenty recognized genera and examination in dried collections throughout the world of preserved flowering specimens representing the fifty-five remaining known genera, comes to the contrary conclusion that:

> The incidence of maturation of fruits is relatively low in the majority of known bamboos; abundant yields occur in relatively few species, principally bamboos not under cultivation. However, this impression should be disciplined by a recognition of the diverse nature of the evidence. In bamboos that have a long flowering period, the number of fruits discoverable at a given moment is usually very low. This suggests that either the set of fruit, or its maturation, is relatively infrequent, in both time and space. Mature fruits more or less promptly fall to the ground. Wild creatures, particularly certain birds and rodents, harvest them either from the plant or from the ground. In North Carolina the destruction of fruits by insects is so high in *Arundinaria tecta* that to get mature seeds Hughes had to dust the inflorescences regularly with DDT. Of *Guadua amplexifolia,* which flowered in 1954 in Puerto Rico, Kennard says, "In spite of many thousands of flowers produced and pollen apparently viable, fruit set was very low. Examination of thousands of spikelets yielded only 1,003 fruits." Only 1 percent of the seeds that were planted germinated.[24]

Taxonomy: Based on reproductive structures.
Since the time of Linnaeus, classification of plants in taxon, or genetically related groups, has been based primarily on reproductive structures. Systematic procedures traditionally grant little taxonomic value to the vegetative parts of the plant. In the case of bamboo, these parts are frequently bulky and/or require special treatment to preserve. Since many bamboos flower so rarely, the difficulty of precise differentiation of species is greatly increased. Since vegetative production generally ceases during flowering, portions of the plant useful for identification such as the fragile, rapidly deteriorating culm sheaths are usually not available for collection at the same time as reproductive structures and are therefore rarely found in herbarium specimens with flowers from the same plant.

Rare flowering creates a bamboo babel.
These are a few of the reasons why "seasoned agrostologists recognize the tentative nature of even the most conscientious and sophisticated treatment of bamboo classification."[25] Like the amorphous monsters that roam many mythologies, bamboo—as known to science—is constant only in its change of shape. *Sinocalamus,* established as a genus by McClure in 1940, was knocked down soon after by the same author, who concedes that the efforts of other botanists to play Adam—assigned in an earlier garden the task of naming plants—will prove equally ephemeral. In some 200 years since 1789, when the first bamboo genus—*Bambusa*—was described on the basis of a species now called *Bambusa arundinacea,* "seventy-five effectively published generic names and over a thousand specific names have been attached to plants generally recognized as bamboos." Many of these names, however, have proved deciduous, and

Bamboo flowers.

many more "are either 'illegitimate' or destined to fall into the limbo of synonymy."[26]

Confusion of names.
It is a crowded limbo. Lawson's *Bamboos* (1968) devotes some hundred pages to detailed descriptions of ninety-five species and cultivars, and then spends seven pages listing their synonyms. The flowering of umbrella bamboo in 1976 permitted Thomas Soderstrom, curator of botany at the Smithsonian Institution, to identify it as *Thamnocalamus spathaceus,* after it had, for "a hundred frustrating, flowerless years, twice been proclaimed a new genus, twice been classified as an existing genus, and four times received new species names."[27] Bamboos as a whole have been treated by some botanists as a separate family of plants, by others as a subfamily of grasses, and by still others as a tribe of Gramineae: The confusion of species merely reflects the uncertainty that surrounds the question of the correct classification of the group as a whole.

Flowers hold hints for genetics and geogeny.
The tiny flowers of bamboo—apart from their taxonomic value, which is worth their weight in botanists—may hold hints relevant to big questions in other fields of science that are not obviously related to their frail stamens: In the article referred to above, unmasking at last the true *who* of umbrella bamboo after a century of conflicting wrong guesses, Soderstrom concludes with the following speculations:

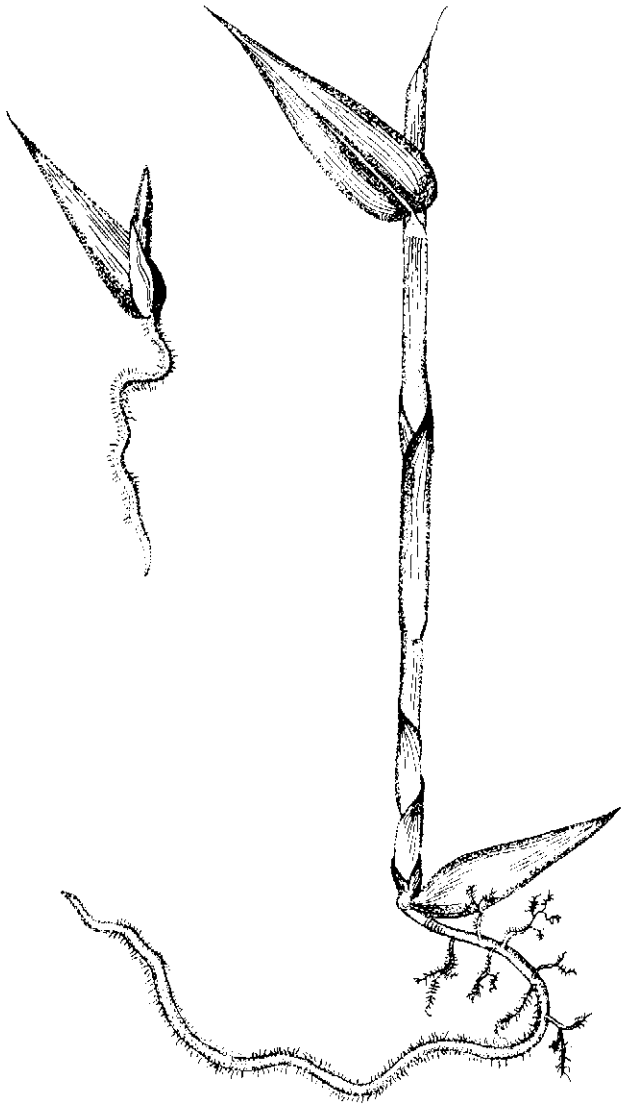
> These newly established taxonomic relationships are of more than just theoretical interest. For example, our new taxonomic studies suggest that the Sino-Himalayan bamboos of the genus *Thamnocalamus* may be related to a bamboo species native to South Africa. Long-distance seed dispersal is not characteristic of bamboos, so the only likely way these now-widely separated species could have originated as a single group is if the regions in which they now grow were once close together. It happens that Africa and Asia were once part of the single land mass Gondwanaland. If the now-dispersed *Thamnocalamus* group originated before Gondwanaland split apart, then *Thamnocalamus* must be a very old genus indeed.

Flowering of bamboos may offer hints on genetics as well as geogeny:

> The peculiar timing mechanism in bamboo cells is also a feature with broad implications. That even a young bamboo specimen grown from a cutting will flower and die if its parent plant is at the end of its predetermined life cycle is a fact of more than passing interest. It may well be that in their possession of an inner timing mechanism, virtually unique among plants, bamboos may offer a handy tool to study aging and genetics.[28]

SEEDLING

Seeds resemble wheat.
The seed of *Melocanna baccifera,* the important and prolific bamboo from east Bengal and Burma, is atypical both in its size—visualize an avocado—and in the habit of its fruit to germinate while still hanging on the branch. More commonly, bamboo seeds have roughly the size and appearance of a grain of wheat and germinate under the litter of the grove. If the seed is viable and abundant, seedlings will literally carpet the areas around each clump or flowering culm in a grove whose reproductive hour has come.



Bambusa glaucescens ***seedling.***

Primary root, telescopic culm.

The seedling at first consists of a primary root and primary culm. The former emerges first, producing root hairs and a few lateral branches that are soon overshadowed by adventitious roots emerging just above the lower nodes of the primary culm. The culm itself is meanwhile elongating through cell division in the meristem just above each node. (The meristem is "a body of tissue in which cell division and differentiation are active or potential."[29]) The culm "opens" like a telescope through the elongation of cells in zones of intercalary growth, that is, zones between mature tissue, which in bamboo culm, branch, or rhizome lie just above the point of insertion of a sheath. McClure notes:

> There is empirical evidence that the sheath may be the origin of substances that control, or at least influence, the process of intercalary growth and possibly also the initiation of root and branch primordia. When Chinese gardeners wish to dwarf a bamboo, they remove each culm sheath prematurely, beginning with the lowest, before the elongation taking place above its node is completed. Upon the removal of a sheath, the elongation above its node ceases. The initiation of branch buds and root primordia on any segmented axis always takes place within a zone of intercalary growth, before the tissues lose their meristematic potential, and while the subtending sheath is still living.[30]

Eighteen-foot seedling.

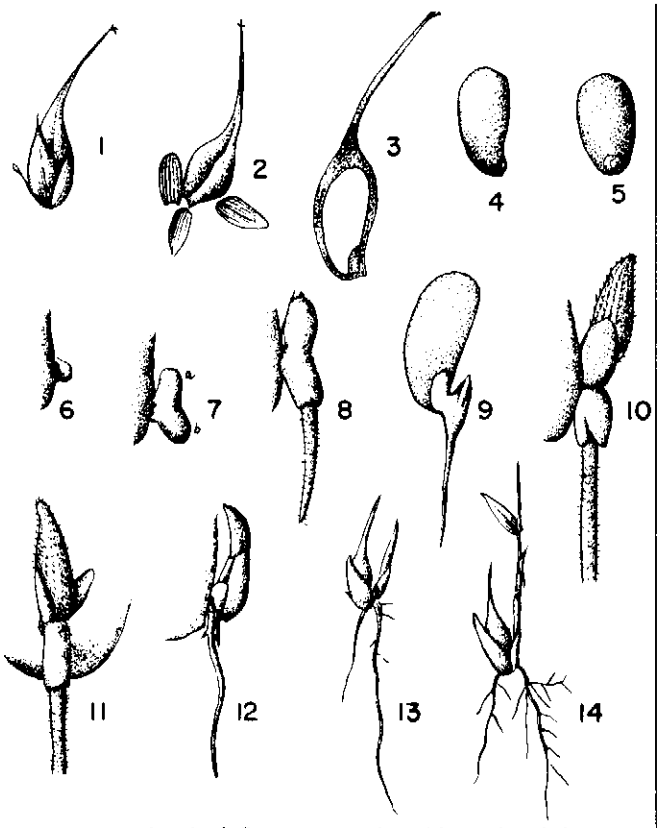
The primary culm of most seedlings—of *Arundinaria, Bambusa,* or *Dendrocalamus,* for example—is commonly only a few inches to around a foot high. *Melocanna baccifera* seedlings at the USDA Experiment Station in Puerto Rico, however, are said to have reached the rather astonishing height of 18 feet. In some species, the primary culm produces secondary culms from buds at the lowest nodes, usually before leafy branches emerge on the first shoot.

Proliferation through tillering from primary culm.

The rhizome generally begins to form only after the growth of several culms by tillering, that is, culms shooting from the base of the primary culm. Once a seedling has developed a rhizome, it has all the structures of a mature plant, but the rhizome's form will change with maturation, which may require three to twenty years, depending both on the species and environmental conditions. Leaves may increase in size with maturity *(Arundinaria tecta)* or, more commonly, diminish *(Melocanna baccifera).* Auricles and/or oral setae of culm sheaths may be larger in seedlings and gradually disappear in adult plants *(Phyllostachys viridis);* usually the reverse is true: Absent in seedlings, they gradually become well developed in plants of increasing maturity. Like most young creatures, bamboo seedlings can be fairly frail, easily crowded out by competing vegetation, roots drowned by too much water, or leaves burnt by too much sun.

DISTRIBUTION

The weather tolerance of bamboo is wide, result-

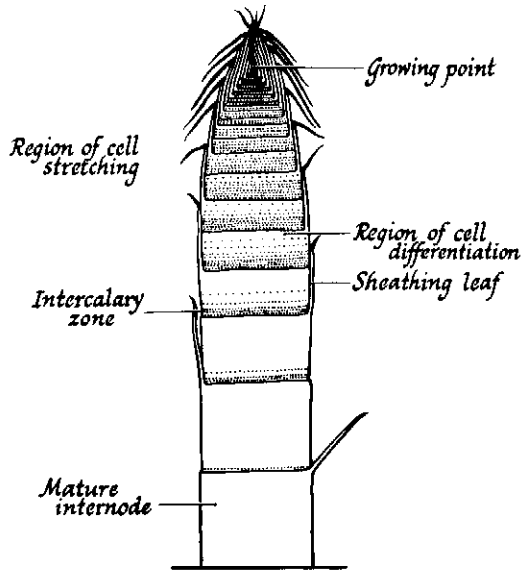


From seed to leaf: five weeks in the life of a seed of **Schizostachyum gracile.** *(1) The fruit as it falls from the plant; (2) stripped of appendages; (3) longitudinal section with the endosperm shown in white; (4) profile of germinating seed with protruding embryo; (5) front view; (6) the fourth day: part of seed, with emerging coleorhiza; (7) the fifth day: coleoptile (a) and coleorhiza (b), the primary culm and root emerging; (8) the sixth day; (9) the same on a smaller scale, with seed and the first tiny sheath of the primary culm; (10) the ninth day: side view of primary culm and root; (11) same day, front view; (12) the eleventh day: forty-eight hours later, on a smaller scale; (13) the fifteenth day: the entire plant, still nourished by the attached seed; (14) day thirty-five: leaf number one—of some 88,000 in mature culms of some bamboos, including* **moso (Phyllostachys pubescens).**

ing in a correspondingly broad distribution. Native to five continents and introduced into Europe, bamboo endures temperature ranges from −4° to 116° F and rainfall extremes from 30 to 250 inches per year. At home from sea level to 12,000 feet in altitude, it ranges between latitudes of 46° N and 47° S. "In the mountains of northern Japan, *Sasa kurilensis* is the most abundant species, growing to timberline at 1,400 m and forming pure communities in places where snow accumulates so deeply that forests are unable to establish themselves. It also occurs on the island of Sakhalin at 46° north latitude, further north than any other bamboo. The southernmost limit of bamboos has been recorded as 47° south latitude for *Chusquea culeou.*"[31]

Pygmy bamboos: fernlike understory of tropical forests.

Although bamboos are found at extremes, they occur most abundantly at low to middle elevations and, with the notable exception of Japan's 662 species, flourish most at equatorial latitudes. Australia, for example, has only 3 native bamboos, the United States, 2 and Russia, 1—while some 113 species are found in India, which lies in the umbilical of that bamboo belt stretching from Ceylon through the Malay Peninsula, southeast China, the Philippines, and New Guinea. Africa is curiously poor in bamboos, having only 3 genera, *Arundinaria, Oreobambos,* and *Oxytenanthera,* while the neighboring Madagascar is rich, enjoying some 30 species and 8 genera. Tropical America, from Mexico to Brazil, is more blessed with bamboos than any other piece of the planet with the exception of Southeast Asia and is the center of world distribution of twenty out of twenty-four known genera of the herbaceous bambusoid grasses. These understory plants of shady tropical forests, almost always smaller than bamboos—without lignified culms, with less developed rhizomes, and bearing foliage resembling ferns or palm seedlings—these pygmy



A diagrammatic section of a shooting culm, which opens like a telescope through rapid division of meristematic tissue just above the nodes. "Meristem" (fr. Gr. **meristos,** *divisible) means a body of tissue in which cell division is either occurring or potential.*

cousins of bamboos are without contemporary or past economic or cultural importance.

ENVIRONMENT

We conclude this brief sketch of the bamboos with a clipped consideration of some of the more important demands they make on their environment that determine their natural distribution, and the possibilities of their introduction where not native.

Moisture.
Bamboos are hungry plants and respond to generous treatment. Moisture is perhaps the foremost necessity of the ideal environment. A good way to observe this is to measure every day a growing bamboo shoot, keeping accurate account of the weather conditions at the same time. It will be found that the curve of growth day by day follows closely that of the percentage of moisture in the air. On rainy or cloudy days with a great deal of humidity, the growth is most rapid; on dry days with a hot sun or a coldish wind blowing, growth is very slow. Bamboos are found most abundantly along the waterways, among the rice paddies, in coastal regions where they can be bathed by sea mists, in the tropical forests and jungles, but never in dry places. All this indicates that moisture is the most decisive factor in determining the distribution of bamboo.

Shelter from winds.
An analysis of the conditions in which bamboo grows best in a natural state will show at once that shelter is also of some importance. Protection on the north and east seems to be of great assistance. The cold winds are usually from the north and northeast, and where temperature is also an object, protection from cutting winds is an advantage and in some places a necessity. The young shoots when they come up are extremely tender, and if in the spring when they first appear they are whipped about as they grow taller and battered by the older canes around them, growth will be much hampered. A southerly exposure is best; breezes from the south are warmer, less violent, and more moist.

Warmth.
The fact that most bamboos occur in the tropics shows that warmth is desirable. It is usually the case that in the presence of warmth and moisture, the work of mineralizing decaying leaves and production of soil goes forward at a rapid rate. A loamy or alluvial soil is ideal for bamboos. The hardiness of some varieties arises chiefly from the rich soil provided for their growth. Slightly sandy or clay soil is not fatal, but small canes and pale leaves indicate conditions are not right.

Surrounding flora: Companion of conifers.
Bamboo is also governed somewhat in its distribution by surrounding flora. Fairchild says it will not grow with oak or chestnut, due probably in part to root excretions. Persimmon trees, on the other hand, do not check shoot production, and some have observed the frequent association of bamboos with conifers.

Taming weather with trees.
"Tree growth helps stabilize air currents, forms windbreaks saving tips of shoots, and moderates surrounding temperature. Metabolic activities of leaves absorb a great deal of the sun's heat. At the same time, transpiration goes on. Added moisture in the air cuts down evaporation of water from the soil where tree roots also help hold moisture. During the rain, a small portion of the precipitation adheres to the leaves, about a sixth, depending on the amount of leaf surface; about a third constitutes surface run-off; while the remainder sinks into the soil. Of this the humus, like a moist blanket over the soil, holds a part; the roots absorb another part, to be made into cellulose or transpired; and the remainder drains off underground."[32]

BAMBOO ADAM

Did all the twelve to fifteen hundred species now swarming the face of the earth begin from one kind of bamboo? Botanists think sympodial bamboos were an outgrowth of monopodial species, an adaptation to climates with prolonged periods of drought. So tropical species probably came from temperate bamboos, but the details of the evolution of the species are not known. If all the bamboos presently inhabiting Asia, Africa, Australia, North and South America grew their way there from some Adam Bamboo, it is further proof of the extraordinary vigor of the plant's flexible survival design. Of course, human migrations were often the most rapid means of travel for many useful "village bamboos," as some botanists call these species symbiotically linked to the earliest human hobos. Bamboo bums were among the first wanderers because bamboo builds a mobile village.

But even without human feet beneath them, rhizomes of *P. bambusoides,* for example, travel about 12 feet a year. At that rate, they could make a mile in some 450 years. In 12.5 million years, they

could circle the earth. In a world some 4,000 million years old, that's fairly fast.

Big Brother.

Apparently there are no records or samples of bamboo fossils. Nobody knows for sure how long bamboos have been striding the planet. But they are among the most primitive grasses, and many species of other genera of Gramineae have been discovered in Eocene and Oligocene beds that date back some 60 million years,[33] enough time for a leisurely monopodial rhizome traveling 2 miles per millennium to wrap five trips around the globe.

Dennis Breedlove, a botanist at the California Academy of Sciences in Golden Gate Park in San Francisco, says that bamboo has been here somewhere between one to two hundred million years (100,000,000 to 200,000,000) or some 200 to 400 times as long as the total lifetime of the human race. Known as "the brother" in Vietnam, bamboo is definitely a Big Brother far more experienced than we are at survival. And sometimes in the groves, watching and wondering how bamboo could best fold its windy green arms around our race, you realize that this big brother is also watching you. Even Walter Hawley, for twenty years director of the USDA groves near Savannah, an eminently matter-of-fact and unmystical man, a perfect paragon of prose, confessed to us with some hesitation, by the groves of *Phyllostachys arcana* in the station, an occasional uncanny sense that the groves knew and greeted him. Looking up at the sunny tips of culms whose rhizomes he'd shipped around the world from Savannah for twenty years, Walter became pensive, especially recalling the loving visits of McClure to the plants he'd nursed from China to the soil where we stood, visits which somehow intensified the feeling that the groves were not only conscious creatures but also *friendly*. "It's funny . . . you come around a corner sometimes and it feels like they're waving at you, trying to say hello . . ."

Country people are often much more in touch with the emotional life of plants and animals than the normal modern urban dweller surrounded mainly by metal and glass and cement, and for some the awareness of plants is not a question to be entertained but an indisputable fact of their experience.

As Jose Valdez explained to us while harvesting a grove of *Bambusa vulgaris* in Santa Maria del Oro (s.w. Mexico): "Plants are people, just like us. You see them, they see you. The earth isn't blind, and the mountains aren't foolish."

CHAPTER 6.

1. McClure 1966:209.
2. Ueda 1960.
3. Lawson 1968:30.
4. McClure 1966:27.
5. Ueda 1960.
6. Simmonds 1963:335.
7. McClure 1966:283. *D. andamanica* is a climber. Exceptionally large self-supporting bamboos are occasionally reported also. "Culms are known of 140–150 feet in length, and Zollinger measured a *Gigantochloa aspera* of 170 feet." Kurz 1876:251.
8. Isaachsen 1946:81.
9. McClure 1952b:18.
10. Needham 1954–1980:vol. iv.2; sec.27 : 61.
11. Lee 1944:127, 129.
12. Porterfield 1927:28–30.
13. McClure 1952b:19.
14. McClure 1966:49–61.
15. Ibid.: 69.
16. Soderstrom 1979a.
17. Ueda 1960.
18. Lawson 1968:36.
19. McClure 1966:288.
20. Simmonds 1963:335.
21. Huberman 1959:40.
22. Junka 1972:22.
23. Ibid.: 22.
24. McClure 1966:86, abridged.
25. Ibid.: 281.
26. Ibid.: 280.
27. Soderstrom 1979b:22.
28. Ibid.: 27.
29. McClure 1966:307.
30. Ibid.: 123.
31. Numata 1979:232.
32. Porterfield 1927:24–7.
33. Lawson 1968:37.

7 SPECIES:
TEMPERATE AND TROPICAL

A new enthusiasm has sprung up, and there is a perfect craze for hardy bamboos. The infection, moreover, is spreading in the New World as well as the Old. There is many a Sleeping Beauty only waiting till some lover shall carry her off from her mountain fastness to awaken under the faint but kindly rays of an English sun.[1]

CRACKJAW NAMES

In *The Bamboo Garden,* Freeman-Mitford suggests that some plants may die of despair, done in by the "crackjaw names" foisted upon them by dusty botanists. Certainly students of bamboo must skirt a similar desperation, trying to remember not only the lists of names but also the shifts in the lists. Bamboo description is an art still in its infancy. We have often included some of the more relevant synonyms, the Latin names useful for reading about bamboo, and the vernacular names useful for talking about it with local people who often know more about species native to their area than can be found in books. In compiling these notes we have relied, in addition to personal experience, primarily on the following authors, whose titles may be found in the bibliography: Freeman-Mitford 1896, Lawson 1968, McClure 1944, 1957, 1966; Young 1945a–b, 1946, 1961. Sources are generally included with each species.

Our objective has not been a dry uniformity of treatment. Descriptions of most garden species of primarily ornamental interest have focused on physical features of the plant. In commercially valuable species, we have often considered use more than appearance. Dimensions given are usually the maximal heights and diameters recorded for the species and obviously will not always be reached under less than optimal conditions. Recommended *Growth Zones,* in the U.S., when recorded in USDA or other publications, have been included. We should stress that these notes are not primarily intended for field identification or for distinguishing between closely related species. Such descriptions, highly technical, are fairly boring to browse. Our aim has been more to give a rough notion of appearance, use, and lore of a fairly broad spectrum of the most common and important bamboos,* focused on, but not limited to, those species available in the United States. It is useful to remember that bamboo's form in all species reflects its environment: "It frequently happens that the same species is found in widely differing conditions of

**Starred species are samples of prominent ones, useful to get to know for a start.*

climate and soil, so changed in character and appearance to puzzle even the elect and completely bewilder the profane."[2]

The *Journal of the American Bamboo Society* (Vol. 1, No. 1, Feb. 1980, 2–11) provides a useful survey of USDA bamboo introductions from 1898–1975. Some 189 identified species and variants are included, together with a large number of introductions in which only the genus is named.

Names in English for common species.
The best way to make at least a small path of meaning through the following forbidding list of Latin names is to become familiar first with English names for the most common species on the market and in the literature. Some oriental names have passed into English usage: madake, moso, muli are a few.

Arrow Bamboo	Pseudosasa japonica
Black B.	P. nigra
Buddha's Belly B.	B. ventricosa
Calcutta B.	Dendrocalamus strictus
Castillon B.	P. bambusoides, var. castillonis
Chinese Goddess B.	B. glaucescens, var. riviereorum
Fish Pole B.	P. aurea
Giant Timber B.	P. bambusoides
Golden B.	P. aurea
Guadua	Guadua angustifolia
Hairy B.	P. pubescens
Hedge B.	B. glaucescens
Henon B.	P. nigra, var. henonis
Japanese Timber B.	P. bambusoides
Kumazasa	S. veitchii
Madake	P. bambusoides
Makino B.	P. makinoi
Medake	A. simonii
Metake	Pseudosasa japonica
Moso	P. pubescens
Muli	M. baccifera
Narihira B.	A. fastuosa
Punting Pole B.	B. tuldoides
Simon B.	A. simonii
Sweetshoot B.	P. dulcis
Thorny B.	B. arundinaceae
Tonkin Cane	A. amabilis
Yellowgroove	P. aureosulcata

TEMPERATE BAMBOOS

For the sake of a preliminary clarity, let's begin with an overall description of the three main genera of hardy bamboos normally encountered in the West, *Arundinaria, Phyllostachys,* and *Sasa.*

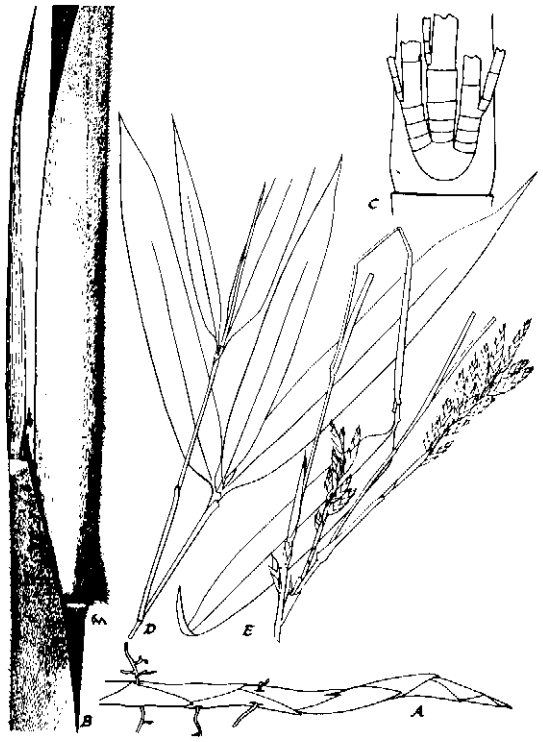
Arundinaria.
Arundinaria derives from Latin *arundo,* meaning reed. The genus is distinguished by the erect, smooth culms, round in cross section, without the groove in internodes that characterizes *Phyllostachys.* The branches open in new culms from tip to base. The culm sheaths are persistent, clinging sometimes for many seasons. The rhizome is generally more actively vagabond, and much more prolific in culms than *Phyllostachys.*

Phyllostachys.
Phyllostachys comes from *phyllon,* meaning leaf, and *stachys,* meaning spike. Culms are usually larger than *Arundinaria,* with a tendency to zigzag from node to node; the internodes are grooved on alternate sides. The branches open from top to bottom, generally in subequal pairs at each node, with a smaller branch between. The culm sheaths fall off quickly, as a rule, though some species such as *P. aurea* may keep their basal sheaths. Culm production is generally much less than *Arundinaria* species; basal diameter, generally greater; the rhizome, usually less vagrant, resulting in tighter groves.

Sasa.
Sa means "thin" in Japanese; *Sasa,* "superslender," refers to the culm, skinny as a pencil. Another version: "The word is believed to be a Japanese corruption of two Chinese words, *Hsai-chu,* or small bamboo."[3] *Sasas* are the most hardy and northern bamboos, covering many mountains in Japan, their country of origin. The smallest of the bamboos, they are distinguished by their leaf size, which is usually larger than any other hardy bamboos and is emphasized by their dwarf habit of growth. The branches are usually solitary, rarely in pairs. The culms are generally curved in the lower portions, and the culm sheaths are usually persistent. The leaves tend to wither at the edges in the species with large leaves.

Arundinaria.
Arundinaria alpina: 45–60 feet by 2½–4 inches.
Native to Ethiopia, Sudan, Congo, Cameroon, Uganda, Tanzania, Kenya, Abyssinia, Tanganyika. Occurring across equatorial Africa from 8,000–10,000 feet altitude in abundant and large stands, its culms are rather thin walled. Used for basketry, house construction, furniture, and crafts.[4]

**Arundinaria amabilis:* "Tonkin cane," 40 feet by 2½ inches, 13°F.
From southern China. Culms are cylindrical, straight, with nonprominent nodes, thin walled but tough, resilient and strong. Small canes serve as plant stakes; large ones used for vaulting and ski poles and especially for split-bamboo fishing



Arundinaria amabilis: ***(A) Rhizome tip. (B) Midculm node of fresh shoot, showing tip and base of hairy culm sheath. (C) Midculm branch complement. (D) Leafy twig. (E) Flowering twig.***

rods, for which this species is preferred above all other bamboos. The chief bamboo on the world market from the 1880s to the 1930s, when the Chinese revolution and World War II halted supply. Its natural advantages were complemented by disciplined grove maintenance and harvesting methods typical of the careful craftsmanship of traditional China. Selection, processing, storage, and packaging for shipping were rigorously controlled. An extensive account of this species is broadly available in a *National Geographic* bamboo cover story, October 1980.[5]

Growth zones in the United States: Gulf region, East Coast probably to Wilmington, North Carolina. West Coast probably to San Francisco area and farther north in sheltered microclimates.

Arundinaria anceps: 15 feet by ¾ inch.
A hyperhardy ornamental from India, native to the northwest Himalayas at altitudes of 10,000–11,000 feet in Sikkim and Bhutan. First introduced into England in 1865. The erect, deep green culms form an attractive hedge and, properly matured and cured, provide excellent garden stakes as well. Called *anceps* (which means two headed, that is, facing two ways or "doubtful") by Freeman-Mitford because its native land was at that time in doubt. The culms, generally straight, sometimes nodding, become heavily burdened with foliage as they mature. Initially and briefly powdered a blue white around the uninflated nodes (as much as 14 inches apart), the glossy green internodes age to a dull green brown. The culm sheaths are deciduous, although they may persist on late shooting plants until the following spring. Glossy on the inner surface, 4–8 inches long, the fresh beige green culm sheaths age to a flat straw. The thin arching branches, three to four per node in the first year beginning some yard or so above the ground, increase as the culm ages, bearing numerous twigs with leaves roughly 4 inches by ½ inch, up to 6 inches long on younger plants. Clearly tessellated, finely bristled on a single margin, midgreen above, a dull grey green below. The culms stand in small tight clumps that are separated a short distance from one another owing to the peculiar nature of the underground rhizomes. These are short, connected by long budless rhizome necks ending in a rhizome proper, from the tip of which a new culm shoots, with additional plants growing from the subterranean basal buds of this "mother" culm by tillering ("throwing out stems from the base of a stem"[6]). This species, *A. fastuosa, A. niitakayamensis, A. simonii, A. tessellata* and *Pseudosasa japonica,* are particularly recommended by Lawson[7] for canes in garden use.[8]

Arundinaria angustifolia: 8 feet by ½ inch.
Unique among bamboos for leaves with the same color on both sides; native to Japan, introduced about 1895 to England from France; the specific meaning, "narrow leaved," was given by Freeman-Mitford. "Often known to sport leaves with white variegations."[9] Rhizomes are known for their vigor and should be confined if you want limited growth.

Arundinaria auricoma: 6 feet by ¾ inch
(Arundinaria viridistriata, Bambusa fortunei, var. *aurea, Pleioblastus viridistriatus).*
Japan is the native land of this "golden haired" *(auricoma)* ornamental with quite distinctive foliage—pea green striped with golden yellow or pure yellow leaves. Named by Freeman-Mitford, introduced into Europe in the 1870s, "by far the best of the variegated species" (Lawson), *A. auricoma* is a favorite potted plant as well as an excellent garden specimen, quite hardy and, though running, not invasive. If cut back in autumn, the leaves return "fresh and sparkling" on the new canes in spring according to Lawson, who is quite vigorous in his admiration of this species. The culms are thick walled, a dark purple green, with uninflated nodes some 3–6 inches apart bearing persistent sheaths hairy at the base and tip. Branches are single, sometimes in pairs, with leaves as large as 8 inches by 1¾ inches, rough to the touch above and smooth below. Their tessellation is fairly noticeable. The species has flowered often in France, Belgium,

and England since the early twentieth century, with usually only a few canes in a stand bearing flowers. Because it is not invasive, it is ". . . a good plant for any position in the garden where it can be allowed to display its beautiful foliage to its full advantage . . . ideal for growing in the ornamental border, or in a sunny position in a rockery. The golden-yellow variegated foliage is outstanding, making this species instantly recognizable from the other yellow variegated species by its sheer brilliance . . . The golden striping varies in both width and number from leaf to leaf."[10]

Arundinaria callosa: 12–20 feet by ½–1 inch. Native to India, in the Himalayas and Khasia Hills, and Assam to 6,500 feet. Used for construction, tying thatch, crafts. Local names include *uskong, uspar, spa* (Khasia).[11]

Arundinaria elegans: 12–20 feet by 1 inch; *jilli* (Naga). From the Naga Hills in India, it grows at 5,000–7,000 feet. Used for interior walls and room dividers, walls of native huts.[12]

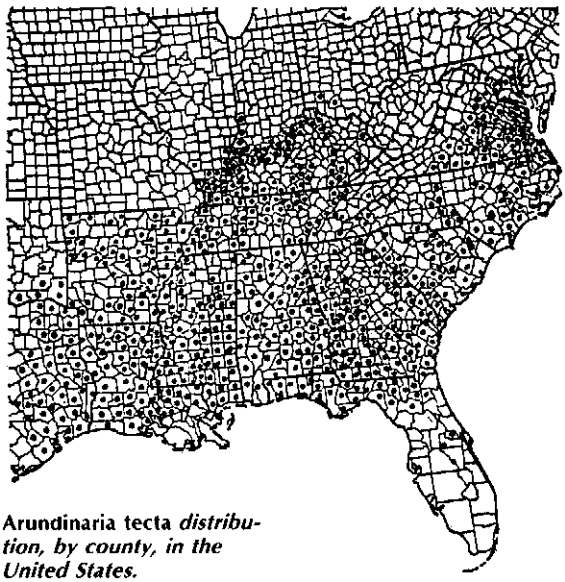
Arundinaria falcata: 15–20 feet by ½–¾ inch; Himalayan bamboo, *ringal, nirgal, nagre, narri, garri, gorwa, spikso, ningalo, kewi, tham, utham, kutino.* Native to India (Ravi), Nepal, Vietnam; used for construction and as a lining for roofs.[13]

**Arundinaria fastuosa:* 25 feet by 1¾ inches, −4°F
(Arundinaria narihira, Bambusa fastuosa, Semiarundinaria fastuosa).
Native to the Honshu, Shikaku, and Kyushu districts of Japan, where this elegant species is called *narihiradake* for an eleventh century mythical hero of romance, it was introduced into France in 1892. *Fastuosa*—stately—the name then given the species in Europe, suits it well: The culms are noble and erect, straight as honor, thin walled, and a deep green with a hint of purple maturing to a yellow brown. The culm sheaths are not persistent: purple outside, a quite distinctive claret on the inner surface, soon weathering to a nondescript dull light brown. "The smooth straw-colored culm sheaths often hang on in a semidetached state for a number of weeks after the new culms have completed their growth and are quite characteristic during that period."[14]

Nodes, uninflated, as much as 1 inch apart, bear two to three short stiff branches on the lower cane, more above. Leaves, four to six to a branch, are up to 10 inches by 1 inch on young canes, smaller as the culms mature. They are clearly tessellated and edged with bristles, a bright green above, dull grey green below. *A. fastuosa* flowered in England in 1935–36, in Japan in 1951, and Lawson (1968) reports several clumps sporadically in flower for many years at the bamboo gardens under his care at Pitt White in East Devon (England). The flowering canes of the species are bizarre in showing above the perfectly cylindrical lower culm typical of *Arundinarias* the peculiar features of *Phyllostachys* species. Beginning above the lowest branches, the internodes are grooved and zigzag from node to node. The species has a very slow moving rhizome and "makes a magnificent solo specimen plant."[15] A beautiful sample of *A. fastuosa* grows next to the giant Buddha in the Japanese Tea Garden in San Francisco's Golden Gate Park. "This splendid bamboo . . . is the stateliest, if not the handsomest, of the hardy bamboos."[16]

Arundinaria fortunei: 4½ feet by ½ inch
(Bambusa fortunei variegata, Pleioblastus variegatus).
A hardy ornamental from Japan, "the best of the white variegated bamboos,"[17] introduced into Belgium in 1863; it is an excellent specimen for a rock garden and an attractive potted plant. New shoots are white with green tips, culms a pale green with uninflated nodes, 6 inches apart, bearing persistent sheaths, thick and straw colored. Branches are thin and long, borne singly, sometimes paired. The clearly tessellated leaves, 8 inches by 1 inch, are covered with fine white hairs, more densely below than above, with prominent midribs. Leaves are dark green striped with white above, fading to a paler green; below, a duller green with less white striation. *Fortunei* is fairly invasive in warm climates; quite hardy but may lose leaves in a harsh winter.[18]

**Arundinaria gigantea:* 30 feet by 1¼ inch, −10°F
(Arundinaria macrosperma).
One of two bamboos native to the continental United States, its "canebrakes" once covered large areas from Virginia to Texas and provided



Arundinaria tecta *distribution, by county, in the United States.*

an effective exit from the South for runaway slaves headed north for freedom before the Civil War. It also provided valued forage for early settlers, who found the cane an excellent indicator of fertile soils. Tests in North Carolina show that cane may be the highest yielding native range in the United States.[19] In the North Carolina coastal plain, it provided 46 percent of forest grazing in the forage types among farms surveyed in the early 1940s. Canebrakes are being drastically reduced in area by fire, uncontrolled grazing, and clearing for cultivated crops. Once killed out, cane comes back quite slowly, requiring several generations for it to naturally reestablish itself.

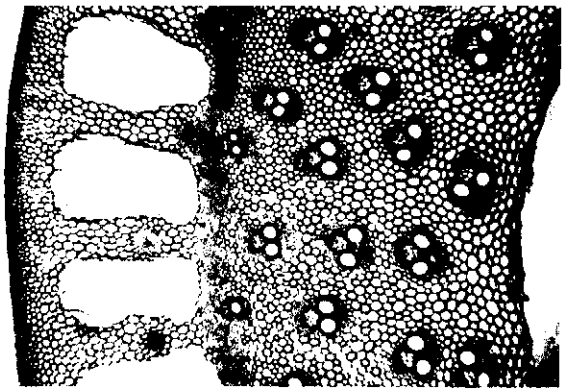
As with other bamboos, flowering of *A. gigantea* can mean a marked decrease in vitality or the death of a grove. "Fox Island was full of game from my earliest recollections up to 1850, when the cane which covered it went to seed and then all died. The seed grew in clusters and resembled oats, and all the animals and fowl got rolling fat from eating it. The squirrels were so fat that their kidneys were covered. This food imparted a delicious flavor to the flesh and we feasted that summer and fall. But this was the end of the cane on Fox Island, as it all died the following winter and was either carried off by high water or rotted on the ground"[20]; from a nineteenth century autobiography written in Indiana. The seed is not only eaten by squirrels; an unidentified larva bores into the seed near the base and devours the starchy endosperm, retarding prompt recovery of flowering groves.

Canebrakes were a favorite hunting ground of the Indians, as they abounded in bears, deer, panthers, wildcats, turkeys, and much small game. Canebrakes were also a good place to hide from whites, who often arrived in new territory along the rivers where canebrakes grew most abundantly. The new settlers not only pastured their livestock on cane, but also drove them into the canebreaks during winter for protection from the cold.

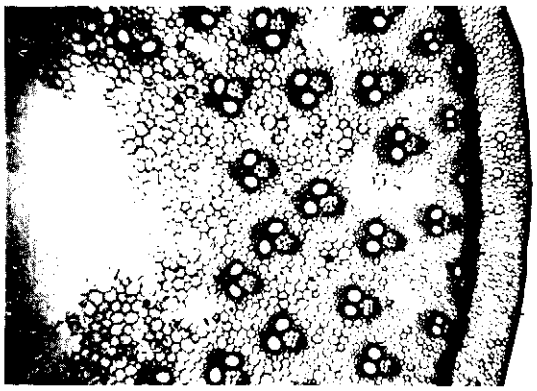
Canes owe their wide distribution to broad tolerance in weather and soil. They grow from sea level to 2,000 feet in the Appalachians, on all types of soil from sandy, rock cliffs and mountain slopes to muck lands *(pocosins)* and rich alluvial areas of the coastal plain—withstanding extremes of temperature from −10° to 105°F.

A smaller cane, *A. tecta,* reaches a height of about 8 feet. Some authors regard it as a separate species; others, as a form of *A. gigantea.*[21] Neither are highly regarded as ornamental plants. "There may well be situations in which a small patch would be of interest and not seriously disfiguring," is the best that Young can say for it,[22] while Lawson regretfully finds it "rather second rate . . . always sad and tattered during winter months."[23]

McClure has this to say about the confusion of species: "Small plants of *A. gigantea* are often confused with switch cane, *A. tecta,* but the two can be distinguished by the branching habit alone: culms 25–30 feet by 2–3 inches, branches short (usually much less than 1 foot) and stiffish, initiated *before* culms reach full height: *A. gigantea.* Culms 12–15 feet by ¼–½ inch, branches long and withy, initiated in the spring, several months *after* culms reach full height: *A. tecta.*"[24] McClure also reports discovering, with a 9x hand lens, air canals in the rhizomes of *A. tecta* that are absent in *A. gigantea,* further indicating they are indeed distinct species.[25]



Cross section of young rhizome of* Arundinaria tecta, *showing air canals that distinguish it from* A. gigantea *(times 25).



***Cross section of young rhizome of* A. gigantea *(times 25). The absence of air canals distinguishes it from* A. tecta.**

Arundinaria graminea: 10–16 feet by ¾ inch *(Arundinaria hindsii,* var. *graminea, Bambusa graminea, Pleioblastus gramineus).*
From the Ryuku Islands of Japan, *A. graminea* was introduced into England in 1877 and into the United States "from a European source, as have been most of our other oriental bamboos of small and medium size."[26] Distinguished by its narrow leaves, "grasslike," as the specific name signifies, it is one of the few hardy bamboos that love the shade. The culms, though thin walled, make very useful garden stakes. Pale green when new, they

The patron saint of* Arundinaria hindsii *is cloud-sweeper Han Shan, the mad poet of Cold Mountain, with his companion broom.

ripen to a dull yellow green with prominent nodes, 6 inches apart, bearing persistent, straw-colored sheaths. The branch complement, initially two or three, becomes in time numerous at each node, particularly in the upper culm. Four to six leaves per branch, up to 10 inches by ½ inch, they are sharply tapered, bristle edged, clearly tessellated, bright green above and dull green below. Flowers frequently. A fairly rapid rambler, not recommended for smaller gardens without barriers to contain its vitality.[27]

Arundinaria griffithiana: 12–20 feet by 1–1½ inches;

khnap (Khasia), *u-spar.* Native to India and Assam up to 4,500 feet. Also grows in Bhutan. Used in house construction and to tie thatch on native houses.[28]

Arundinaria hindsii: 12 feet by 1 inch

(syn. *Bambusa erecta, Pleioblastus hindsii, Thamnocalamus hindsii. Kanzan-chiku*).

Native to China, this bamboo has been grown for centuries in Japan and was introduced into England about 1875. Very hardy, grows easily in all soil types, even in deeply shaded sites. Thin-walled, olive-green culms make a good hedge—producing useful garden canes. The culms are distinguished by clusters of branches at the top giving them a top-heavy appearance. Rather rambunctious rhizome should be confined if you want to curtail travel. Often confused with *A. graminea,* but this species has coarser and broader leaves (Lawson 88–9). "As the shoots have good flavor and sprout all year round, it is cultivated as a good vegetable in southern Kyushu, where there is often a shortage of summer vegetables. Legend says it was transplanted from the Han Shan or Cold Mountain Temple in central China" (*Fuji Guidebook* 1935:35).

In Japan, this species is named for Kanzan or Han Shan, the Cold Mountain poet whose work has recently become more familiar in the West. He was often pictured with a broom and a fellow loonie-illuminate, Shih-te (Jittoku in Japanese). This species was used to make brooms, and was called "cloud sweeper" by the Japanese.[29]

Taimin-chiku, another bamboo that Satow treats under the name *A. hindsii* (var. *graminea*) has internodal lengths up to 2 feet and was early a favorite of flute makers. After a marvelously sweet flute was made from it at a certain monastery, the emperor required the area to furnish the court with culms of this "flute bamboo" as it was then called. "It is said that flutes made from stems of this bamboo grown on rocks and crags can be heard to a great distance."[30]

Arundinaria hookeriana: 15–20 feet by ½–1½ inches.

Native to India, Sikkim, and west Bhutan, an excellent potted plant, this semihardy ornamental is easily identified by its bright yellow canes with pink and green stripes. The culms are thin walled, blue green when new, ripening to their more distinctive golden yellow with green striations that show a deep pink in more sunny locations. The papery, straw color culm sheaths are moderately persistent, particularly at their base, which may remain clinging to the plant long after the rest of the sheath has weathered away. The uninflated nodes, some 8 inches apart, often show a dark blue ring, sometimes striped light green or yellow. Branches, many at each node, bear leaves quite variable in size (from 3–12 inches by ½–1½ inches) smooth blue green above, sea green below with fine white hairs at the midrib base. Not invasive. In its native lands, it grows at 4,000 to 6,500 feet but is not terribly hardy. "Usually requires some greenhouse shelter. It can be grown outdoors only in very favored areas. As a tub plant in a conservatory, it is highly valued for its wealth of delicate foliage and the uniqueness of its coloring."[31]

Arundinaria humilis: 2–6 feet by ¼ inch

(Arundinaria fortunei, var. *viridis, Bambusa nagashima, Nipponocalamus nagashima, Pleioblastus nagashima, Pleioblastus humilis).*

From Japan's Honshu and Kyushu districts, this good ground cover for erosion control is called *humilis* ("low") by Freeman-Mitford for the modest stature of its dark green culms. It has dull purple new shoots with deciduous purplish sheaths drying to pale yellow. Uninflated nodes are up to 5 inches apart, bearing two to three quite long branches (3 feet). Pale green leaves (8 inches by ¾ inch) are somewhat hairy on the

dull matt green lower side. *A. humilis* is distinguished from the similar *A. vagans* by its thinner culms, longer branches, and smooth upper surface of its paler leaves. Its rhizomes are also less vagabond but are fairly invasive and can present a problem in weather friendly to its growth. "Owing to the thinness of its canes, it is often cut to the ground during very cold weather. It invariably recovers to form a green carpet before the following summer is very old."[32]

Arundinaria intermedia: 8–12 feet by ½ inch; *nigala* (Nepal), *parmick* (Lepcha), *titi nagala, prong nok.* Native to the east Himalayas of India and Nepal, Bhutan, and China, *intermedia* grows to 7,000 feet. Internodes are 15–30 centimeters. (6–12 inches) Thin-walled culms are used to make mats to cover walls and partitions.[33]

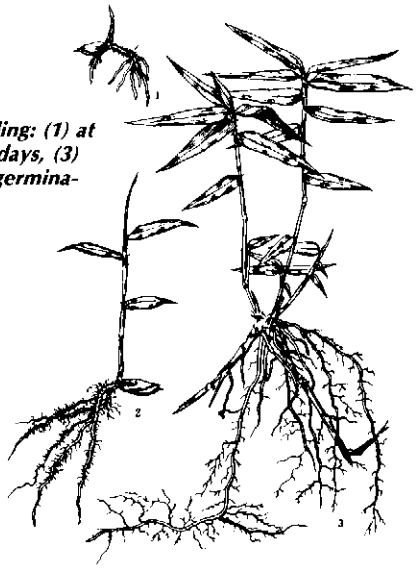
Arundinaria khasiana: 10–12 feet by ½ inch; *namlong, u-kadac namlong.* Native to the Khasia Hills of India, where it grows from 5,000 to 6,000 feet, this species is often cultivated and is widely used in wattle and daub walls of houses.[33]

Arundinaria mannii: 30 feet by ½ inch; *beneng* (Khasia). Native to India, the Jaintia Hills, and Assam, it grows to 3,000 feet. Used as withes for binding frames of houses and for firewood.[34]

Arundinaria prainii: 28 feet by ¼–½ inch; *kevva, sampit* (Naga). Native to India, the Khasia, the Jaintia and Naga hills up to 9,500 feet. Slender culms are used as lath for walls of houses.[34]

Arundinaria racemosa: 5–15 feet by 1 inch; *maling* (Nepal), *phyeum miknu, mheem, pheong, pithiu.* Native to India, Sikkim, Nepal, and China, this bamboo grows from 6,000–12,000 feet. Used for roof construction and as matting for houses.[35]

Arundinaria simonii.



A. simonii *seedling: (1) at 10 days, (2) 30 days, (3) 150 days from germination.*

**Arundinaria simonii:* 18–24 feet by 1½ inches, 0°F

(Bambusa simonii, Bambusa viridistriata, Nipponocalamus simonii, Pleioblastus simonii). Native to China and Japan, introduced into France in 1862 by M. Simon, then French Consul in China, the culms are thin walled but extremely strong, ideal for garden use. The species was energetically recommended as worthy of more commercial notice by 1957 Clemson College (North Carolina) tests; fishing poles, plant stakes, and shuffleboard cues were among mentioned uses. The erect, olive green culms with physical qualities resembling the excellent *A. amabilis* have uninflated nodes up to 14 inches apart. The culm sheaths are quite persistent, dull green with a hint of purple at the edges, glossy on the inner surface. They weather rapidly to a dull brown.

Branches are solitary in the first year on larger culms, then in pairs, finally a dozen or more on mature culms, growing in a distinctive steeple formation. Smaller culms may have numerous branches even the first year but always with one dominant. Three to six leaves grow on a branch, up to 12 inches by 1¼ inches on older culms, smaller on younger ones. Leaves taper to a fine tongue and are clearly tessellated. A strong green above, the underleaf is bicolored, especially towards the tip: a grey green on one side of the prominent midrib, on the other, a simple green. The species is noninvasive and makes a fine hedge. Strongly recommended for garden planting owing to its attractiveness and the useful properties of its canes for fencing, trellises, stakes, and gates. Quite hardy and vigorously abundant. "An occasional leaf may have one or more slender white stripes, and in the cultivar 'silverstripe' the striping becomes extensive."[36] Hardy to Teaneck, New Jersey, on the Atlantic coast.[37] Pacific coast, to regions where temperatures as low as 0°F do not occur

more often than every three to four years.[38] In Japan, this species, known as *metake* or *Pleioblastus simonii,* covers 14,374 hectares, representing 8.5 percent of the groves and providing 9.6 percent of their harvest. After *Phyllostachys bambusoides* (61 percent) and *P. edulis* (22.4 percent) metake is Japan's main commercial bamboo species.[39]

Arundinaria tecta: 12–15 feet by ¼–½ inch.
"Switch cane" is one of two native species of bamboo in the continental United States, along with *A. gigantea.* See discussion under that species.

Arundinaria tessellata: 5–20 feet by ½ inch.
A South African bamboo used by Zulu warriors in constructing their hide-covered shields and by other forest tribes for arrows and spear handles, this species grows in such vast stands in its native lands that Bamboesberg—"bamboo mountain" in Afrikaans—is called after it. Named by Munro (1868) for the tessellation of its leaves, but this feature is much less prominent than other more distinctive characteristics of the species; the quite persistent white culm and branch sheaths are its most unique identification, not to be confused with any other hardy bamboo. The crowded lower nodes distinguish it as well, resembling somewhat those of *Chusquea culeou,* whose bottle-brush form in the branch complements *A. tessellata* also shares. New shoots are "densely covered with fine white hairs at first, smooth later, pale creamy green, often flushed with pale pink streaks."[40] The thin-walled, erect canes, a pale green maturing to deep green, age to deep purple, more intense in a sunny site. Uninflated nodes, 1½ inches apart at base, up to 8 inches at midculm, bear the persistent though paper-thin sheaths, a clear white the first year, ripening later to a dull creamy color. Downed initially with hair that weathers off, the 3–5 inch sheaths are glossy on the inner surface. Branches usually appear in the second year of growth. In time, numerous short twigs and branches grow at each node, bearing three to four leaves 2½–5 inches long by ½ inch wide. These are mid-green above, matt green below and slightly hairy at the base; tessellation is fine but clear and bristled more heavily on one edge than the other.
"Bergbamboes" or "mountain bamboo" as it is known in South Africa, is most at home in moist ravines 5,000–8,000 feet in elevation. "Under cool conditions it cannot be called invasive."[41]

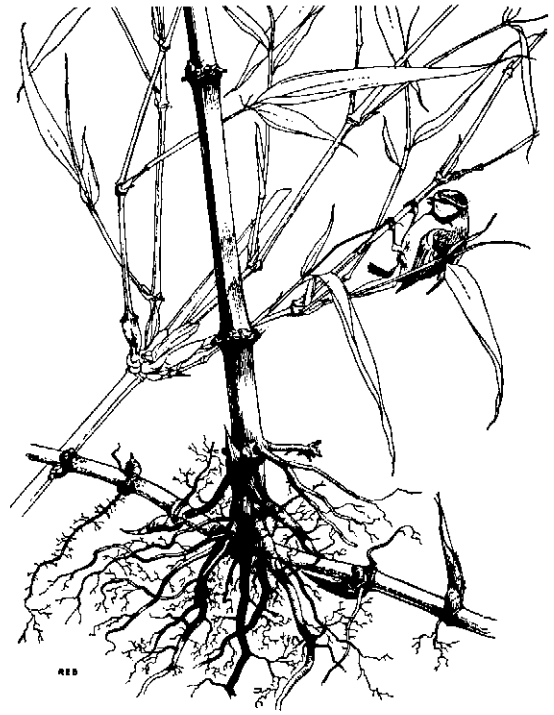
Arundinaria vagans: 3½ feet by ½ inch
(Pleiblastus viridistriatus vagans).
Introduced in 1892 from its native Japan into England, it is extremely hardy and vagabond (*vagans* means wandering). Excellent for erosion control, this species was used on large Victorian estates for game cover. The culms, bright green ripening to a deep olive, are faintly flushed with purple when shooting and bear persistent sheaths at uninflated nodes (some 6 inches apart), which are "bloomed conspicuously on the lower portion with a loose white powder."[42] Branches are usually solitary, sometimes paired, moderately long, with 6 inch by ¾–1½ inch leaves hairy on both surfaces (especially near the base below), bristle edged, with a prominent yellow midrib and clear tessellation. Mid-green above, matt grey green below, in winter they are characteristically withered at tips and margins. Distinguished from the similar *S. pumila* by absence of hairy ring at the base of culm sheaths and from *A. humilis* by thicker culms, shorter branches, and hairy leaves that are a darker green. *A. vagans* is "the most invasive bamboo of them all, and if allowed to get out of control can become quite a serious pest . . . will smother all but the toughest opponents."[43] This vitality, a problem in limited space, recommends the species as a stabilizer on steep banks or wherever erosion robs the soil.

Arundinaria viridi-striata: 1½–2½ feet by ¼–½ inch.
A dwarf ornamental Japanese bamboo with yellowish striped leaves that tend to curl in full summer sun, so semishady locations are preferred. Leaves, 2–5 inches long, smooth above, velvety below, in late summer lose the stripe that earned its species name. Grows better in more northern climates as far north as Philadelphia on the East Coast and on most of the Pacific Coast. Mulch is recommended in more northern winters.[44]

Arundinaria wightiana: 10–15 feet by 1 inch; *chevari.* Native to western and southern India and Ceylon (Sri Lanka), it is especially abundant on the Nilgiris. Used for matting and basketry.[45]

Chimonobambusa.

**Chimonobambusa marmorea:* 6 feet by ½ inch
(Arundinaria marmorea, Arundinaria kokantsik, Bambusa marmorea).
Native to Japan (Honshu district), introduced into France in 1889, "marble" bamboo is named for the unusual color of its new sheaths and shoots. The shoots are "pale green mottled brown and silvery white. Tipped and striped with pink . . . maturing to a dull purple or deep purple when grown in a sunny position."[46] The culms are quite thick walled, with prominent nodes some 6 inches apart, bearing persistent sheaths that are "fringed at the base with white hairs. Purplish at first and dotted with pinkish grey mottling . . ." aging to "dull silver grey." Branch complement is typically three, one short and two long. Sometimes up to five branches grow at a node, but always with one branch dominant. Leaves, 6 inches by ½ inch, end in a distinctive tongue, bright green above, a flat grey green below with



Chimonobambusa quadrangularis: ***rhizome and root system, with a leafy branch.***

a prominent midrib and moderate tessellation. Can be fairly invasive once established, though it makes a good potted plant. Attractive hedges of this species can be seen at the Japanese Tea Garden in Golden Gate Park in San Francisco.[47]

The genus name comes from its rare habit of shooting in late fall or winter (from Greek *cheimōn,* meaning winter).

**Chimonobambusa quadrangularis:* 10–30 feet by ¾ inch, 19°F.

Native of China, introduced in Japan many centuries ago, the species is distinguished, as its name indicates, by square culms. Thick walled, with strong, close-grained wood, they serve well as garden stakes. Initially dark green, the stems mature to a brownish green with occasional dark purple blotches. The swollen nodes, much larger than the slender internodes, are 5–6 inches apart and ringed with adventitious roots. Three to five branches, which snap off easily, are the usual complement at each node. The leaves, up to 9 inches long by 1¼ inches wide, are an olive green above, matt green below. The rhizomes wander, but the species is not terribly invasive as only a few canes are produced each year. In addition to its use as a striking garden ornamental, square-stem bamboo is recommended for tub plantings. Healthy stands of it can be admired in San Francisco at the entrance to the Japanese Tea Garden in Golden Gate Park.[48]

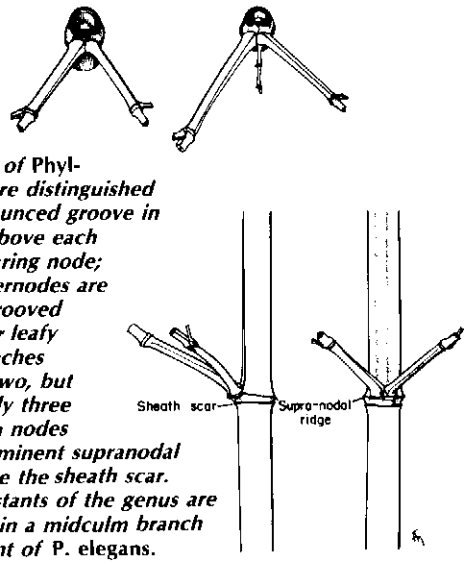
This bamboo owes its abnormal shape to supernatural powers, according to the Chinese traditions that surround its groves, although in different areas different occult agencies are credited with its creation. Some say Ko Kung, a famous fourth century alchemist, stuck his chopsticks—shaved square—into the ground of a certain monastery. There they rooted magically and produced this species.[49]

Phyllostachys.

These bamboos include many resistant species with excellent technical properties of importance to human economy. Natural stands in China are found mixed with both deciduous and coniferous forests: after its seedling stage, the shallow rhizome does not compete with deep-rooted trees.

Of 750 bamboo plant introductions into the United States by 1957, 200 were of this genus, whose center of distribution is in China where nearly all known species are native. Some were introduced to Japan long centuries ago, where only four species of *Phyllostachys* and their variants grow in general cultivation, but these make up the biggest part of Japan's bamboo harvest. In China, this genus is the principal source of paper pulp, a major source for construction and handicrafts, and an important source for edible shoots.

Of *Phyllostachys,* twenty-four species and eleven cultivars or variants have been introduced into the United States, mainly through the efforts of USDA plant explorers, especially McClure. "The potentialities of this group of plants in the economy of the United States, especially for paper pulp and for use in watershed protection and erosion control, remains largely untouched."[50]



***All species of* Phyllostachys *are distinguished by a pronounced groove in the culm above each branch-bearing node; branch internodes are similarly grooved above their leafy twigs. Branches —usually two, but occasionally three —rise from nodes with a prominent supranodal ridge above the sheath scar. These constants of the genus are illustrated in a midculm branch complement of* P. elegans.**

An 1829 Japanese illustration of an unidentified variegated species whose culm resembles square stem bamboo.

Phyllostachys angusta: 21 feet 8 inches by 1 5/16 inches.

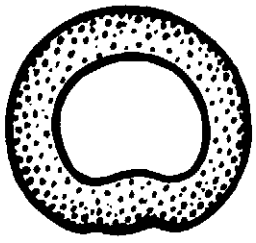
Sha Chu, "stone bamboo," in its native China, the species name refers to hard culmwood that is used in fine furniture. Nonprominent nodes are 3–10 inches apart. Midseason shoots are free of bitterness. Introduced into the United States in 1907, the species is hardy as far north as Washington, D.C., on the East Coast.[51]

Phyllostachys arcana: 27 feet 3 inches by 1 5/16 inches.

Introduced into the U.S. in 1926 by McClure from China, where its early shoots are eaten and culms are used for matting and lanterns. The specific *arcana* ("hidden") refers to "the peculiar way in which the dormant buds at lower culm nodes become partially covered by the extension of the nodal ridges." This trait and "the tall strongly arched ligule of the lower culm sheaths" serve to distinguish the species from *P. nuda,* which it resembles.[52]

**Phyllostachys aurea:* 30 feet by 1 5/8 inches, −4°F.

Native to China, cultivated in Japan for many centuries where it is known as "phoenix bamboo" and "fairyland bamboo." The Latin specific "golden" can be misleading since canes are usually more green than gold, especially in shaded areas. Widely cultivated in Europe since the 1870s, popular in South America, it was the first *Phyllostachys* introduced into the United States, in Alabama, 1882. The short, swollen internodes and zigzag basal nodes of *P. aurea* are a striking characteristic of the species, and the ornamental value of this easily identified distinction is exploited in China and Japan for walking sticks and umbrella handles. Bone hard but superflexible, with the inflated basal internodes forming a natural handle to snuggle in the human hand, "fish-pole bamboo" (as the species is known in the United States) has probably landed more fish in the southern states, where it was most available, than any other single material. Excellent, too, for fan handles, clothes poles, bean poles, and plant stakes—

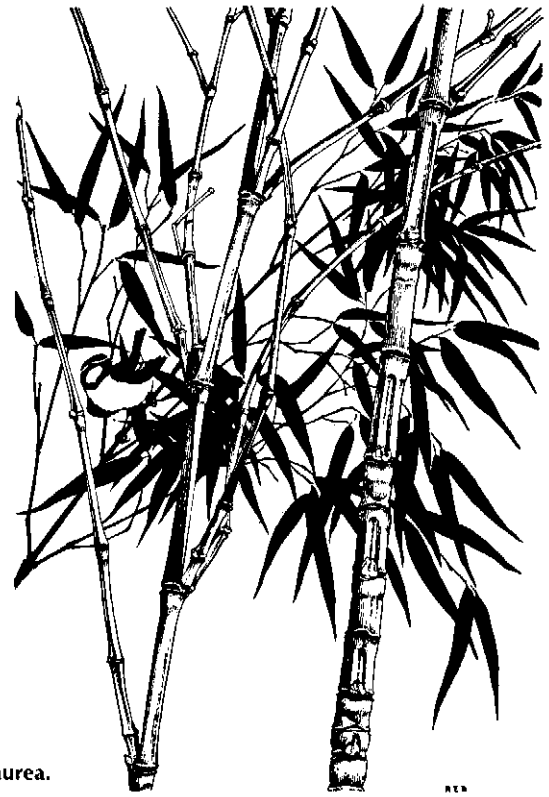


Cross section of a grooved internode of* Phyllostachys aurea *(golden bamboo).

The crumpled lower culms are a distinguishing feature of* Phyllostachys aurea, *among the most common hardy bamboos in the Western garden.

branches are left on to stake tomatoes and other climbers since untrimmed canes offer more support. Pipe stems are made from branches and the tips of culms, which always stand stiffly erect in this species, even with the light source from a single side during growth.

New shoots are edible, olive green to rosy with small brown spots. The culms taper from a stout base to a slender tip, a bright green aging to a pale yellow. Only basal culm sheaths are persistent—for years—rosy, with violet streaks, maturing to a dull yellow. Nodes are crowded at the base, 1–3 inches, up to 10 inches and more in midculm. A cylindrical swelling, like an eggcup in shape, occurs below each joint in culm and branch. Stiff and upright branches are typical of the genus and occur in unequal pairs, with sometimes a third between, beginning as high as twenty nodes (13 feet) above ground in one mature 27-foot culm examined. Internodes of branches, like those on culm, are deeply grooved ("sulcate") on alternate sides above branchlettes. Leaves, two or three per twig, 4–7 inches by 3/4 inch, are bristle edged more prominently on one margin, smooth on both surfaces, light pea green above, sea green below. Rhizomes are very slow moving, and the species forms fairly tight clumps. Hardy at least to Washington, D.C., on the Atlantic Coast, Pacific Coast to British Columbia.[53]



P. aurea.

Phyllostachys aureosulcata: 33 feet by 1½ inches, 0°F

(*P. nevinii*—early misidentification in United States).

Native to Chekiang Province in China, introduced into the United States in 1907, "golden-groove" bamboo, as its name indicates, is distinguished by a greenish-yellow sulcus (groove) on internodes above the point of insertion of the branch complements. New culms are rough to the touch and, in the first yard or so of some, two to three nodes are strongly "geniculate" (from Latin *geniculatus,* meaning "with bended knee"); that is, they are abruptly bent at a sharp angle in a zigzag fashion. This kink, an oddity rarely found in any other species, increases the ornamental interest of the species but decreases its commercial use. Its wood, in fact, is not of superior quality, but mature culms are recommended for fishing poles, plant stakes, and similar uses. Next to *P. aurea* and *P. bambusoides,* this species is one of the most widely cultivated bamboos among the *Phyllostachys* in the United States, owing to its ample distribution by the USDA in the 1920s as a "stake and forage bamboo." Edible midspring shoots are free of bitterness, even uncooked. When shooting, "the species is easily recognized by the pale green culm sheaths with many slender whitish stripes, a pair of prominent auricles at base of the lance-shaped sheath blade which is bristled except on sheaths near base of culm."[54] Leaves, two to three to a twig, are 6 inches by ¾ inch on new culms, smaller on older ones. Hardy to Philadelphia on the Atlantic and to the Columbia River or farther north on the Pacific Coast.

**Phyllostachys bambusoides:* 30–72 feet by 1–5¾ inches, 0°F

(*Phyllostachys quilioi, Phyllostachys reticulata,* among Japanese botanists).

This is the "Japanese timber bamboo" in the U.S. trade. In Japan, of 662 species, 61 percent of the bamboo harvest comes from *madake* (mah-dáh-kay), as this species is known there. The most versatile and preferred among all *Phyllostachys* for construction and other industrial uses, madake is excellent also for erosion control. Erect culms lean towards the light at grove margins. Mature ones are fairly thick walled; small culms of a new grove are suitable for plant stakes, rug poles, and fishing poles. Good quality split fishing rods have been made experimentally with *P. bambusoides.* Culms are durable living or dead: Stalks of madake are known to remain leafy up to twenty years in a grove.[55] Edible midspring shoots are somewhat bitter raw.

Among twelve species carefully tested during World War II for ski pole construction, this species and *A. amabilis* were found superior to

Phyllostachys bambusoides: ***The tip of a new shoot, a leafy twig, and an enlarged insert of a leaf sheath's auricles and shoulder bristles.***

Phyllostachys bambusoides, *var.* castillonis.

all others for workability.[56] Planted perhaps more widely in the United States than any other bamboo, it is most recommended by the USDA to succeed in U.S. rural economy since its use spans construction and edible sprouts.

Two other species resemble madake: *P. vivax* culms are less straight, more thin walled, earlier shooting, and faster growing. *P. viridis* has pigskin dimpled internodes that can be felt with sensitive fingers or seen with a 9x lens.

Madake is recommended in the Gulf region, the East Coast to Washington, D.C., West Coast from central California north, where winters are cool but not below 0°F.

Four distinct horticultural forms of *P. bambusoides* are found at the USDA Plant Introduction Station near Savannah, Georgia, where rhizomes of many hardy bamboos are free for the digging in February each year.

ALLGOLD. Sometimes listed as *P. sulphurea.* Culms, much smaller than madake type, are bright yellow at sheath fall, with lower internodes sometimes thinly striped with green. A white or cream stripe is found also on occasional leaves.

CASTILLON. "Undoubtedly the most impressive member of the Phyllostachys for ornamental purposes."[57] The 30-foot bright yellow culms show green slashes on grooves of culms and branches. "Golden brilliant bamboo," the Japanese call this cultivar, which they consider a spontaneous mutation of *P. bambusoides.* Highly prized as an ornamental in Japan and China, it was introduced into European cultivation in France by 1886. From there, rhizomes found their way to the collection of Henry Nehrling in Florida at some date prior to a 1916 USDA introduction directly from Japan. Culms are considerably smaller than the species type, and the edible late spring shoots are less bitter.

Castillon grows to full size in an area 25 feet across at least, after eight or more years. Initial planting should be 6–8 feet apart each way. Recommended in the United States in the northern Gulf region, East Coast probably to Norfolk, Virginia, and milder parts of the West Coast. Hardy to 5–0°F. A few degrees lower severely injures the plants.[58]

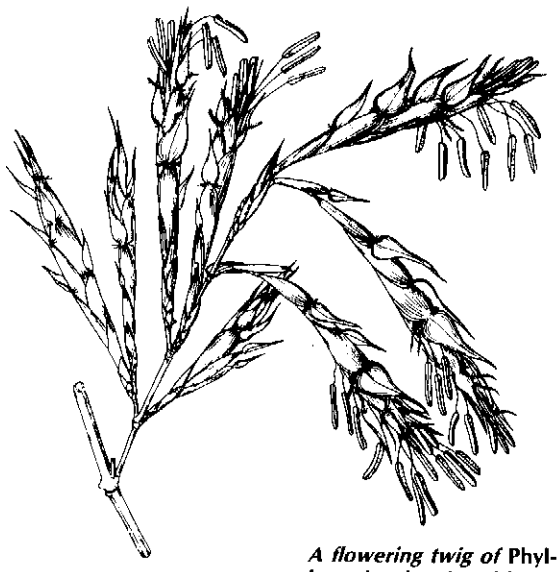
SLENDER CROOKSTEM. 48 feet by 2¼ inches, about 0°F. Many culms of this cultivar are curved near the base, and they are more slender for height than species type. It was introduced in 1925 into the United States from China by McClure. Culms are preferred to species type for harvesting nuts. Dark green above, brilliantly glaucous below, the leaves of this bamboo once seen in a slight breeze are not soon forgotten.

Zones: northern Gulf region, East Coast to Norfolk, Virginia, milder parts of the West Coast.[59]

WHITE CROOKSTEM. Introduced into the United States by McClure from Dragon Head Mountain, Kwangtung, China. Like slender crookstem, serpentine curves bend base of culms, which differ in plentiful deposits of white powder that obscure the green of old culms almost completely.[60]

Phyllostachys bissetii: 22.5 feet by ⅞ inch.
Entered the United States from Szechwan, China, in 1941. "One of the hardiest Phyllostachids under observation" at Savannah, Georgia, USDA groves, and one of the first to shoot in spring.[61]

Phyllostachys congesta: 25 feet 4 inches by 2⅛ inches.
Arrived in USDA Savannah groves in 1907 from Chekiang, China. Midseason shoots have only a slight bite. Strongly tapered, stiffly erect culms with nodes 3½–10½ inches apart are similar to *P. nigra* var. henon but are more tapered and less coated with powder.[62]



***A flowering twig of* Phyllostachys bambusoides.**

Phyllostachys decora: 23 feet 7½ inches by 1¼ inches.

Mei Chu, "beautiful bamboo" in its native China, this species entered USDA Savannah groves in 1938, sent by McClure from Hoi-wai Monastery in Kiangsu. Midseason shoots.[63]

**Phyllostachys dulcis:* 40 feet by 2¾ inches, −4°F.

Culms with prominent nodes are strongly tapered, often strongly curved. Shoots lean towards light during most active growth, then straighten up. The early spring shoots are among the most esteemed in central China where the species is native, but the culms are weaker for industrial purposes than many other species. May produce culms of maximal size in seven to eight years under favorable conditions, but drought retards this bamboo. Endures 0°F or less but won't prosper in frequent low temperatures. McIlhenny rated it the most rapid and prolific of bamboos at the Avery Island, Louisiana, groves. Recommended zones: Gulf, East Coast to Washington, D.C., West Coast except extreme north and south. *P. dulcis* grows in USDA Glen Dale, Maryland, groves, where − 4°F is the minimum temperature.[64]

Phyllostachys elegans: 32 feet 5 inches by 2¼ inches.

Distinguished from others of this genus by small lance-shaped leaves especially hairy on the lower surface. Rusty brown freckles appear on culms in direct sun; internodes are 1–12 inches long. It was sent from Kwangtung (1936) and Hainan (1938), China, by McClure to USDA. *Fa chuk,* the Cantonese name for this species meaning "flowered" or "embroidered bamboo," refers to the marking on the culm sheaths. In Kwangtung, it is known as *man sun* or *man chuk,* "elegant shoot," or "elegant bamboo," a beautiful ornamental with superior flavor and quality sprouts and relatively poor culmwood.[65]

Phyllostachys flexuosa: 30 feet by 1¾ inches, −8°F.

Native of China, the culms of this bamboo are either straight or flexuous and zigzag. Midspring edible shoots are acrid raw. The medium quality wood is good for all standard bamboo uses for poles of this dimension. Hardy to −8°F with minor foliage damage.

Zones: East Coast to Philadelphia; West Coast possibly to Vancouver.[66]

Phyllostachys glauca: 33 feet 6¾ inches by 1⅞ inches.

From Kiangsi, China, to the USDA in 1926 via McClure. The early midseason shoots are relatively free from bite and bitterness, even raw.[67] (Culms of this species, misnamed *P. flexuosa,* have been tested by Glen in 1954.)

Phyllostachys makinoi: 60 feet by 2⅝ inches.

Introduced by USDA from Taiwan in 1951, this species has stiffly erect midseason shoots. During World War II, culms were imported into the United States for rug poles and as (an inadequate) substitute for *A. amabilis* in split-bamboo fishing poles, when supply of *A. amabilis* was cut off from mainland China. One of the most important commercial bamboos for scaffolds and constructions in Taiwan, curiously undistributed in the United States.[68]

Phyllostachys meyeri: 35 feet by 2 inches, −4°F (estimated).

Introduced to the United States from China in 1907 by F. Meyer. Tests show mature culms of "Meyer bamboo" are among the finest, strongest, and most versatile of the *Phyllostachys* genus. Excellent for fishing poles and nut harvesting; the longer poles are used for deep-sea fishing, and larger ones make good heavy plant stakes. Branched tops of all culms make excellent supports for vines such as lima beans and sweet peas.

Zones: Gulf region, East Coast to Norfolk, Virginia, most of West Coast.[69]

Phyllostachys nidularia: 33 feet by 1½ inches.

"Big node bamboo," *Taai Ngaan Chuk* in its native China, has culms that are strong and useful whole but do not split well: The lower internodes are frequently semisolid to solid. "Vigor and widespread occurrence in China suggest this species is worth trial for soil and water stabilization on hills or levees and for production of shoots, which are both among the best for flavor and the earliest on the spring market in Canton, where its shoots with chicken is a favorite dish."[70] *Pat Sun Chuk,* another Cantonese name for the species, meaning

Phyllostachys nigra *(black bamboo) is a favorite ornamental, with excellent culm wood prized for cabinetwork and furniture by the Japanese.*

"writing brush bamboo," derives from the shape of these shoots, thought to resemble a brush. Another name, *So Pa Chuk,* "broom bamboo," presumably suggests use: The big nodes offer a good grip on the handle, perhaps.

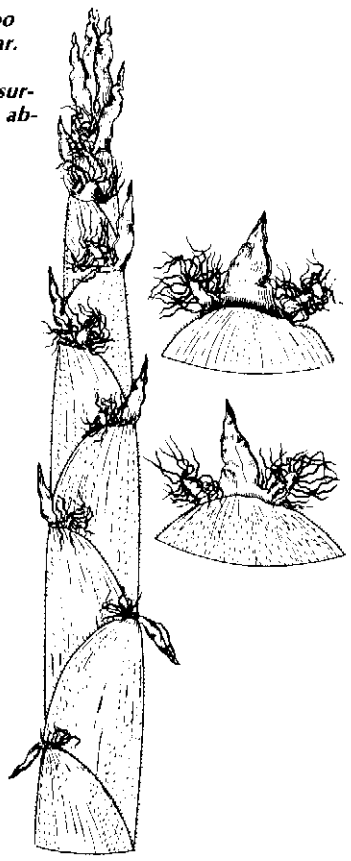
**Phyllostachys nigra:* 26 feet by 1¼ inches, 0°F.
Native to southern China, anciently introduced to Japan, in 1827 black bamboo became the first hardy oriental bamboo to ramble in Western ground. Its color, striking stance, and hardiness soon made it a fairly common pleasure on a privileged lawn: "All sun-worshippers who wing their flight southward with the swallows, know the Black Bamboo as one of the chief ornamentals which grace the gardens of the Riviera."[71] The distinctive culms are first green but weather usually by the end of the first season to a fairly or very solid black. Some culms, more rarely, mature to a deep purple black. Late midspring shoots are edible. Culms are thin walled but durable. "The wood is hard enough for substantial cabinet work, and it is very cleverly used by oriental cabinet makers for decorative panels and inlays, as well as for interior finish."[72] If growing as an ornamental, remember that culms darken well in direct sunlight.[73]

Phyllostachys nigra, cultivar Bory: 0°F.
This bamboo has larger, more erect culms than the typical form, and it develops a few scattered purplish to brown spots in place of the black spots that ultimately cover lower internodes more or less completely in black bamboo. Bory has extremely limited distribution in the United States.[74]

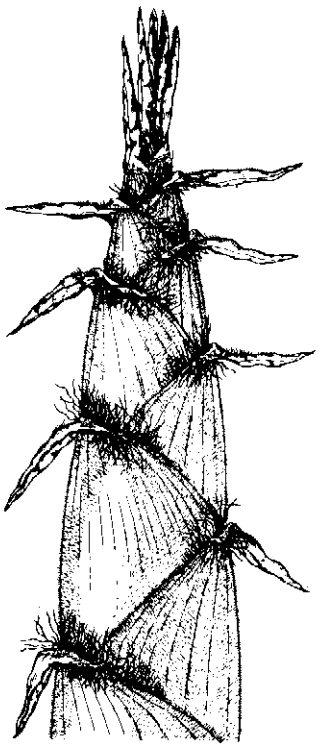
Phyllostachys nigra, var. *henonis:* 54 feet by 3½ inches, −5°F.
Henon is among the hardiest and handsomest of Phyllostachids, native to southern China and long cultivated in Japan, from whence it was introduced into the United States in 1909. Henon bamboo is a graceful giant, thin walled, but strong. Culms subjected to comparative tests during WWII in pound resistance and fracture characteristics showed somewhat superior performance to *P. bambusoides.* Late midspring shoots are edible but remove bitterness with a few changes of water when boiling.
Freeman-Mitford calls Henon "the most beautiful member of a beautiful family . . . which droughty summers do not parch and ice-bound winters do not starve."[75]

Botanists believe Henon bamboo to be the true biological species and the smaller form to be of garden origin. But the smaller was described first so botanical etiquette requires considering Henon as the cultivar. Its culm is not black, contrary to its Latin name. "Looking upward from within the clump, one sees a canopy of green foliage supported on innumerable slender pillars. Young culms are rough to the touch, until the short stiff hairs fall away from the surface; freshly divested of their protecting sheaths, they show a surface bright green, perceptibly dimmed by a thin film of white powder. In age, the powder, now off-white, all but obscures the original green, or where sun and rain beat upon the culms and swaying leafy branches sweep their surfaces, a rich lustrous golden hue may be revealed.

"As compared with mature culms, the young shoots are quite distinctive and infinitely more spectacular in their appearance, which they derive principally from the enveloping sheaths. These are an unspotted tawny hue, tinted with wine, and softened by an inconspicuous coat of spreading brown hairs. The sheath blade stands at the top, flanked at its base by a pair of well-developed dusky auricles fringed with lavender bristles. Pressed against the culm or slightly spreading, the durable and persistent sheath blade suggests a bright, krislike [wavy] dagger. As its functions are completed, each sheath, in turn, takes on a light tan color, beginning along the upper margins as the tissues dry. Presently it falls to the ground, revealing its polished inner surface and leaving behind the



Shoot of henon bamboo* (Phyllostachys nigra, *var.* henonis), *with sheaths showing inner adaxial surface (above) and outer abaxial view (below).



***Shoot of* moso (Phyllostachys pubescens).**

fresh and spotless green internodes of the young culm."[76]

Zones: Gulf, East Coast possibly to Philadelphia; West Coast probably to the Columbia River or even farther north.[77]

Phyllostachys nuda: 34 feet by 1⅝ inches, −8°F.

From Chekiang Province, China, introduced in the United States by Frank Meyer in 1908. Its edible shoots are excellent, though a trifle bitter when raw. Mature culms are not highest industrial quality but are locally useful for fishing poles, plant stakes, and all-around farm use. This species is quite hardy, perhaps the hardiest *Phyllostachys.* It flourishes near Glen Dale, Maryland, USDA Plant Introduction Garden at the land of George Darrow.

Zones: Gulf, from southeast Texas eastward; East Coast to Maryland; West Coast probably to Vancouver. At −8°F *P. nuda* suffered minor leaf damage near Washington, D.C.[78]

Phyllostachys propinqua: 23 feet 4 inches by 1¼ inches.

Sent by McClure in 1928 from Kwangsi, China, to the USDA. It looks like *P. meyeri* but lacks the narrow line of white hairs on the base of culm sheaths of that species. Midseason shoots.[79]

**Phyllostachys pubescens:* 38–70 feet by 3–7 inches, 3°F

(*Phyllostachys edulis; Phyllostachys mitis* by earlier botanists).

Moso, as this major commercial species is known in Japan, was introduced there from China around 1738. From there it arrived in Europe about 1880 and around 1890 reached the West Coast of the United States. This species covers some 2 million hectares of China's present 2.9 million hectares of bamboo forest and represents roughly 22 percent of the bamboo harvest in Japan.[80]

The culms are larger in diameter for their height and more tapered than most bamboos. "The largest and handsomest of the giant hardy bamboos . . . with foliage more feathery and attractive than any other species of the genus."[81] Although the quality of the early to midspring shoots is a bit below many other *Phyllostachys* species, their large size makes moso the central species in the bamboo-shoot business in both China and Japan. The winter shoots of moso, on the contrary, are excellent, an esteemed delicacy.

Dig moso early as December, undeveloped, supertender.

An infrequent, prized abnormality in* moso *culm development produces tortoiseshell bamboo.